AUG 20 1928

ARMY ORDNANCE

VOL. IX JULY-AUGUST, 1928 No. 49

MAIN ARSENAL BUILDING, ARMORY SQUARE, SPRINGFIELD ARMORY

SPRINGFIELD ARMORY
Col. H. W. Schull, Ord. Dept., U. S. A.

MANUFACTURING AT SPRINGFIELD ARMORY
Lieut. Col. John H. Read, Jr., Ord. Dept., U. S. A.

EXPERIMENTAL WORK AT SPRINGFIELD ARMORY
Maj. Herbert O'Leary, Ord. Dept., U. S. A.

OVERHAULING THE SERVICE RIFLE
Lieut. J. E. McInerney, Ord. Dept., U. S. A.

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The Journal of the Army Ordnance Association

Pledged to Public Service in Effecting Industrial Preparedness for War as Our Strongest Guarantee of Peace

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Published by
THE ARMY ORDNANCE ASSOCIATION
806 Mills Building, Washington, D. C.

Issued Bi-Monthly. Single Copy 75c.
Subscription rate: Continental U. S. $4.50 per annum, foreign $5.00, in advance. Entered as second-class matter August 14, 1920, at the Post Office at Washington, D. C., under the Act of March 3, 1879. Additional entry at Richmond, Va.

Volume IX | JULY-AUGUST, 1928 | Number 49

CONTENTS

	Page
The Administration Building, Armory Square, Springfield Armory	Frontispiece
Springfield Armory By Col. H. W. Schull, Ord. Dept., U. S. A.	1
Manufacturing at Springfield Armory By Lieut. Col. John H. Read, Jr., Ord. Dept., U. S. A.	9
Experimental Work at Springfield Armory By Maj. Herbert O'Leary, Ord. Dept., U. S. A.	17
Heat Treatment and Finish of Small Arms at Springfield Armory By P. W. Oliver	28
The Bursting of Rifles in Service By A. L. Woodworth	33
Overhauling the Service Rifle By Lieut. J. E. McInerney, Ord. Dept., U. S. A.	36
The 14th Ordnance Company (Maintenance) at Springfield Armory By Lieut. Arthur D. Elliot, Ord. Dept., U. S. A.	43
Tracer Ammunition, Part III. By Capt. S. P. Meek, Ord. Dept., U. S. A.	44
Superintendents and Commanding Officers, Springfield Armory, 1794-1928	46
Announcement—Tenth Annual Meeting, Army Ordnance Association	47
Editorial	48
Springfield Armory—Other Things the Army Did Besides Fight—Our Tenth Birthday—The National Matches.	
Professional	50
Radium Atomite, A New Explosive—"New Methods in Exterior Ballistics"—Development of U. S. Rifle, Caliber .22, Model 1922—Machine Gun Activities at Springfield Armory.	
Personnel	54
1928 Reserve Officers' Training Camp at Springfield Armory—Summer Training for Ordnance Reserve Officers.	
Books	62

"No great nation in the world, knowing that America has prepared itself for defense, will ever venture to attack it. It is the best insurance against aggression and it is costing the people of the United States almost nothing in its preparation."

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THE Army Ordnance Association is a national organization of American citizens pledged to industrial preparedness for war as our nation's strongest guarantee of peace.

THE Association endeavors to keep alive an interest in and knowledge of the design, production and maintenance of munitions. Other than a few manufacturing arsenals—six in all—there is no peace-time industry for the production of ordnance. Should war unhappily come again, industrial America will be called upon to produce munitions in great quantity and of intricate and unusual design. In an emergency time will not permit careful study or long preparation for the production of munitions. The problem is one of vital concern.

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ARMY ORDNANCE, the journal of the Association, is published solely for the purpose of disseminating information on the progress of our munitions developments so that American industry may at all times know its responsibilities to the common defense.

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To assist in effecting industrial preparedness for war as being one of the nation's strongest guarantees of peace;

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To commemorate the services rendered by the Industry of the Nation and by the Officers and Civilian Employees of the Ordnance Department in the wars in which the United States has been engaged.

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806 Mills Building, Washington, D. C.

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The Administration Building, Hill Shops, Armory Square, Springfield Armory, Springfield, Mass.

ARMY ORDNANCE

VOL. IX JULY-AUGUST, 1928 No. 49

Springfield Armory

By Col. H. W. Schull,* Ord. Dept., U. S. A.

THE United States Armory at Springfield, Mass., known officially as the Springfield Armory, is one of the six major manufacturing arsenals of the Ordnance Department of the Army. It came into existence as a national institution as the result of an Act of Congress "to provide for the erecting and repairing of Arsenals and Magazines, and for other purposes" which was approved April 2, 1794.

Col. H. W. Schull, Ord. Dept., U. S. A.

Long before the passage of this act, however, even before the nation was born, the present site of the armory and the town of Springfield had been intimately associated with the military service of the country, in that since the earliest period of the Revolutionary War it had, through the wisdom and foresight of General Washington and his associates, been selected as the place where one of the important laboratories or depots for the preparation, storage and issue of military supplies of all kinds should be located. The establishment of several depots or arsenals in different parts of the country for the manufacture, storage and supply of war munitions to the troops operating in the several theaters became matters of great importance very early in the Revolutionary War.

AS EARLY as 1776 Colonel Henry Knox, one of General Washington's experienced commanders, recommended "that there be one or more capital laboratories erected at a distance from the seat of war, in which shall be prepared large quantities of Ordnance Stores of every species and denomination. That at the same place a sufficient number of able artificers be employed to make carriages for cannon, of all sorts and sizes, ammunition wagons, tumbrils, harness, etc., etc. That as contiguous as possible to this place a foundry for casting brass, cannon, mortars, howitzers, be established upon a large scale." These recommendations were strongly indorsed by General Washington and finally adopted by the Continental Congress.

The first of these depots was established at Carlisle, Pennsylvania, this place being centrally located with reference to the various theaters of operations and sufficiently remote to be reasonably secure against capture. It soon developed, however, that for the supply of operations based on New England another depot in the northeastern section of the country was very necessary.

The records of this period show that there was considerable difference of opinion as to where the depot or laboratory for the New England section should be located, the choice being between Springfield and Brookfield, Mass., and Hartford, Connecticut. Each of these places had some advantages and for the selection of each there were a number of active partisans. Brookfield, which is about 30 miles east of Springfield, was apparently considered because it was in an upland country sufficiently remote and difficult of access to an enemy to make it reasonably safe for the storage of supplies, and was also at that time the largest town in Western Massachusetts. In December, 1776, the Council of Massachusetts actually passed a resolution establishing a magazine or depot at this place. General Washington, however, as soon as he heard of this plan objected to Brookfield on the grounds of unsuitability of the location for various reasons, among them being the fact that it was too inaccessible and that it lacked facilities for water transportation. At the same time he suggested Hartford, Connecticut, as a better location. Hartford had the great advantage of being at the headwaters of navigation for seagoing vessels on the Connecticut River. This fact, however, exposed it more or less to enemy attack from the sea, which at the time was a serious consideration, especially as the English were in possession of New York and could quite readily ascend the river as far as Hartford with the men-of-war of that period.

Springfield, Mass., was finally chosen at the site for the depot upon the urgent representation of General Knox for the reason that it combined the advantage of having water transportation facilities for small vessels with the fact that it was safe against attack by larger seagoing craft, and in addition, was on the regular direct

*Commanding Officer, Springfield Armory, Springfield, Mass.

line of travel between the Hudson River and Massachusetts Bay. Other considerations also influenced the choice of Springfield. Among these are mentioned in the correspondence of the period, the fact that in the vicinity of this town were a number of sites where water power could be obtained from the streams that empty into the Connecticut River, where saw mills were located, and the fact that timber useful for building purposes was, at that time, quite plentiful and easily obtained.

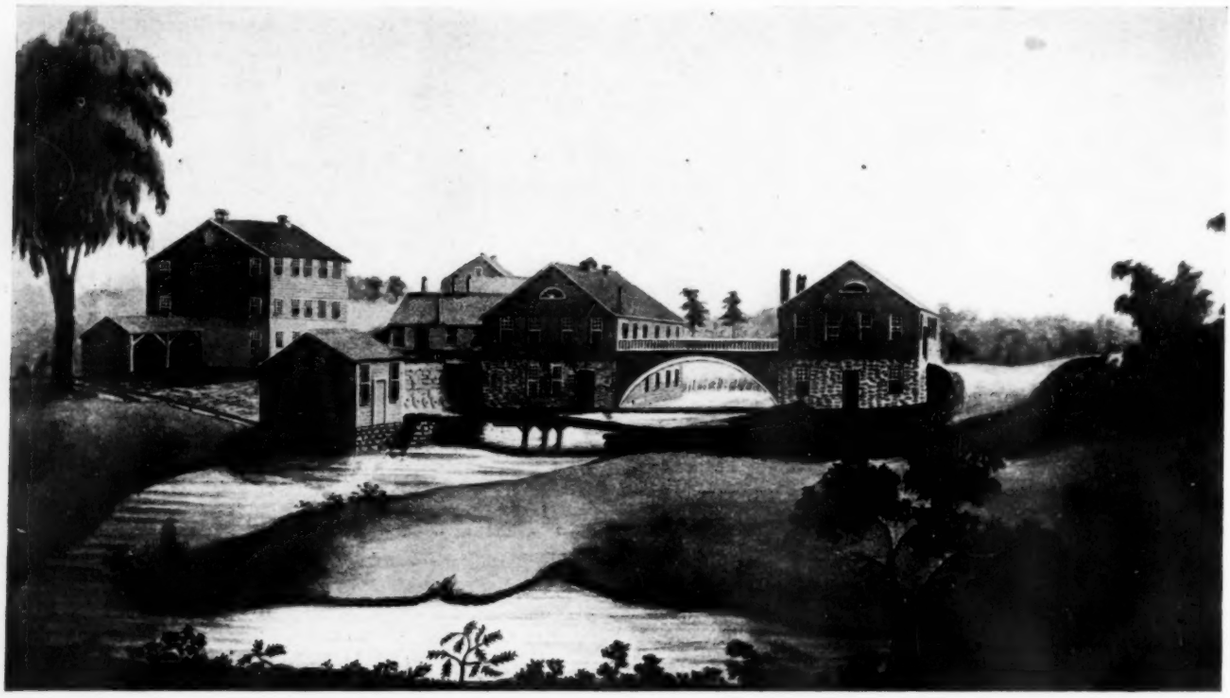
IMMEDIATELY upon obtaining the approval of General Washington of the selection of Springfield, plans for providing the necessary buildings for housing personnel and storing the military supplies were put into effect. A number of buildings in the town were rented for this purpose and in 1777 and 1778 barracks, shop buildings, storehouses and a powder magazine were erected on the high ground back of the town, known as the Training Field, which ground was leased for the time being from the town for these purposes.

The first work done at the new depot or laboratory appears to have been the making and filling of cartridges for muskets, the manufacture of carriages for cannon and general repairs to muskets and other military stores. Very soon after operations began, steps were taken to transfer to this depot all surplus stores along the north Atlantic coast and scattered through the New England area to make them secure against capture by the enemy. Springfield thus rapidly became a storage, supply and repair depot of the first importance. Its location placed upon it the responsibility of preparing and supplying war munitions of all kinds to troops operating against the enemy forces on the coast, to expeditionary forces against Canada and to the whole northeastern frontier.

An idea of the activity of the Springfield Depot in 1777 may be gained from the following observation of a captured British officer of General Burgoyne's Army who passed through the town of Springfield that year:

"This place is a veritable magazine for the storage of weapons for the Americans; and it also has a small but very well built armory or arsenal.

"We saw here various parts of artillery with their trains, and among other things, twelve entirely new 4-pounders of French make. The store or magazine houses were filled from top to bottom, and workmen of all trades were seen in the houses engaged in the manufacture of ammunition wagons, guns, etc."



The Upper Water Shops, Springfield Armory, in 1830.

The activities of the Springfield Depot embraced the entire problem of army supply, including ordnance and ordnance stores, food, fuel, forage, clothing, tentage, etc. Responsibility for proper functioning of the depot devolved upon three officials; a Director of Ordnance, Lieut. Col. David Mason, a Deputy Quartermaster General, Lieut. Col. William Smith, and a Commissary for Military Stores, Col. Ezekiel Cheever. It supplied the extensive military operations connected with the repulse and capture of the invading army of Burgoyne, the operations against Howe and St. Leger in 1777, the Expeditions against Canada in 1779 and the incessant and ubiquitous demands from the Hudson River Valley, the seacoast towns and even the more remote western frontier.

The successful termination of the campaign of 1781 which brought the Revolutionary War to a close saw also the gradual demobilization of the major military activities at the Springfield Supply Depot. Most of the employees were discharged, and there followed a period of several years of inactivity. Adequate provision, how-

ever, was made to care for the military stores that had been accumulated there during the war, especially of the powder which, of all things, was at this period one of the most difficult to obtain in quantity.

The Middle Water Shops, Springfield Armory, from an old print.

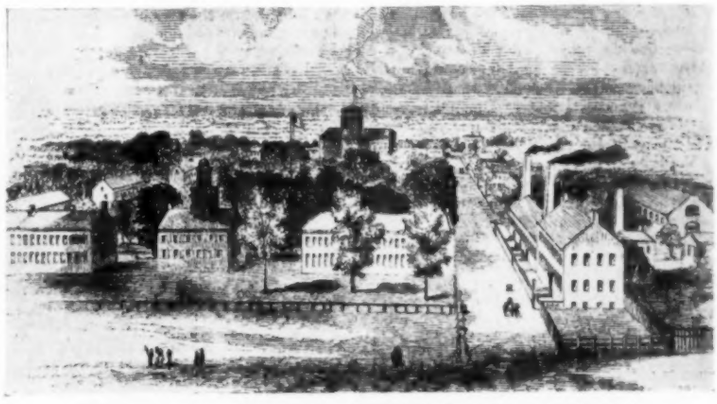
ON APRIL 26, 1782, the Congress passed a resolution directing "that the Secretary of War take order for establishing good and sufficient magazines for the reception of the public ammunition at the following places, to-wit—at Springfield in the State of Massachusetts; at West Point in the State of New York; at Yellow Spring in the State of Pennsylvania; and at New London in the State of Virginia." Steps were accordingly taken at once to obtain authority from the town of Springfield, Mass., to erect an adequate powder magazine. This magazine was built on the high ground known as the Training Field, land held at the time under a lease, not far from the site of some of the present Hill Shops buildings. It was used for the storage of a considerable quantity of powder for a period of 60 years. In 1842 this powder magazine was torn down because it offered too great a hazard to residences growing up in the vicinity.

The following is an extract from the diary of General Washington dated October 24, 1789, relating to a visit made by him on that date to the Depot at Springfield: "Reached Springfield by 4 o'clock and while dinner was getting examined the continental stores at this place, which I found in very good order at the buildings (on the hill above the town) which belong to the United States.

"The barracks (also public property) are going fast to destruction, and in a little time will be no more, without repair.

"The laboratory, which seems to be a good building, is in tolerably good repair, and the powder magazine, which is of brick, seems to be in excellent order, and the powder in it very dry."

Less than a year later Mr. William Loughton Smith of Charleston, S. C., traveling through Springfield observed that there were "public stores of arms and accoutrements, and cannon belonging to the United States; they are kept in very good order. I think there were 8,000 stands of arms and a large quantity of gun powder."



Armory Square, Hill Shops, Springfield Armory, 1850-1861.

THE foregoing outline covers briefly the activities of the general depot or arsenal at Springfield from the time it was established in 1777 throughout the Revolutionary War period and the years immediately following the war until it was made a national institution under the provisions of the Act of Congress approved April 2, 1794.

It is evident from contemporary records that the primary function of this depot during the Revolutionary War was that of a general base for the manufacture, maintenance and supply of ammunition, gun carriages and other ordnance materials to the troops operating north of Philadelphia. Small arms such as muskets were also repaired in large quantities but none of these articles appear to have been manufactured at the Springfield Depot during this period. Apparently neither the manufacture nor the importation of small arms conforming to a standard type or design suitable for military purposes was undertaken on any considerable scale anywhere in this country during the period of the Revolutionary War. This was not because the use of small arms and the art of making them were not well developed in this country at the time. On the contrary, practically all the men in the colonies were more or less skilled in the use of firearms, and gun-making and repairing seem to have been carried on in a comparatively large and profitable scale throughout the country.

The methods of standardized manufacture involving the use of interchangeable parts, in the modern meaning of these terms, were unknown in those days, however, and there were no factories anywhere in America where the production of standard arms in quantities sufficient to supply large bodies of troops could be successfully undertaken. The consequence of this state of affairs was that throughout the entire period of the Revolutionary War the soldiers of the Continental Armies were armed with many different kinds of muskets, some made in one State armory, some in another, some imported from France, others from the Dutch, Spanish and French West

Indies, and the problems of tactical use, supply and maintenance must therefore have been very complicated and difficult. The experiences of the Revolutionary War undoubtedly convinced the military authorities of the new government that the adoption of a standard military arm and the development of adequate facilities to manufacture such an arm in quantities sufficient to supply the troops were matters essential to proper military preparedness.

The largest number of muskets of any one type in use in the American Armies during the Revolutionary War was supplied from France. These were mostly of the standard military design manufactured at the French National Armories at Charlesville and St. Etienne. The latter armory had been established and in operation as a national institution since 1669. It was found that these French muskets, all having been made to a similar pattern under more or less similar methods of manufacture and inspection in the government arsenals, possessed many advantages over the heterogeneous collection of arms from British and other sources that were then in use. The French musket accordingly became the model that was followed when the manufacture of arms was subsequently undertaken at the national armories in this country.

Officers' Quarters, Springfield Armory.

THE Act of Congress approved April 2, 1794, which directed the establishment of three or four arsenals with magazines for the safe-keeping of military stores provided also for the establishment of a national armory for the fabrication of small arms at each of these arsenals. President Washington selected Springfield, Mass., as the site of one of the arsenals authorized by this act of Congress for many of the same reasons as had determined the choice of this location for the Revolutionary War depot and for the additional reason that this depot was by that time firmly established under military control and that a considerable number of work shops, storehouses, barracks, magazines, houses and other buildings had been erected and were available. Another cogent reason which operated strongly in favor of the selection of Springfield was the fact that a relatively large number of gunsmiths, armorers, blacksmiths and artisans of all kinds, many of whom had gained experience in their trades at the Springfield Depot during the long period of the war, had remained in the vicinity and were available for employment at the new arsenal.

Steps were soon initiated looking toward the acquirement of land for the construction and expansion of the plant as it became necessary. The old records show that parcels of land were obtained from the "Inhabitants of the Town of Springfield," from the "Town of Springfield," from the "Trustees of School Fund," from the "City of Springfield" and from many individuals. The total amount of land so acquired amounted to 297 acres and 18 rods, which is the approximate acreage of the Armory today. This land was obtained under ninety-six separate leases, the earliest being dated June 23, 1795, and the latest August 2, 1870. The size of the parcels of land deeded range from three rods, the smallest, to 30 acres, 94 rods, the largest.

Of the total amount of land comprising the Armory today 73 acres and 40 rods are included in the Hill Shops area, made up of Armory Square, Federal Square and a smaller adjacent square known as the Spring Water Lot. The remaining 223 acres, 138 rods, are included in the Water Shops area. The major portion of this area is covered by the waters of the Water Shops Pond above the Government dam which furnishes water power for the Water Shops plant. These two areas, which are about one mile apart, are the sites of the two plants comprising the Springfield Armory, known as the Hill Shops and the Water Shops. The Hill Shops, with the buildings pertaining to administrative headquarters, storage, manufacture, etc., occupy the old Training Field and other ground on which the buildings of the Revolutionary War depot were located. The Water Shops buildings are located on Mill River and were built there originally so as to utilize the water power of this stream in its descent from the high land east of the city to the Connecticut River. The growth of the two plants has been normal and has kept pace with the demands for increased facilities since the foundation of the institution. No trace remains of any of the wooden buildings which constituted the depot or arsenal prior to

1800. The first permanent building erected at either plant was the brick powder magazine which was built at the Hill Shops in 1782. This building had a capacity for 4,000 barrels of powder. It was torn down in 1842.

THE early plan of the construction of the Hill Shops plant was that of a group of buildings arranged in a quadrangle in that section of the grounds known today as Armory Square. The first permanent building in this group was a two-story brick building known as the "Brick Store." This building was completed in 1807-1808. During the Civil War a third story was added to this building and it came to be known as the West Arsenal. It has for many years been used as the enlisted men's barracks and is still in very good condition.

Shortly after the construction of the West Arsenal there was completed in 1808-1809 a two-story brick building to house the stocking and filing shops. This building was burned down in 1824 but was rebuilt the same year and parts of it are now used as the Model Shop and to house the Small Arms Museum. In 1881 a two-story office building for use as an administration building was erected just south of and in line with the Stocking and Filing Shop. This building is still used for the purpose for which it was originally built. Later another shop building was erected 80 feet south of the office building and for many years the two shop buildings flanking the office building were known as the North Shop and the South Shop. In 1825 and 1830 respectively the buildings known as the East Arsenal and the Middle Arsenal were erected along the south side of the quadrangle and in line with the West Arsenal. The Middle Arsenal, when it was built in 1830, was the first three-story building erected on the grounds. The East Arsenal and the Middle Arsenal are still in use as store houses.

Other buildings belonging to the manufacturing and storage plant in Armory Square were erected as necessity for them arose in the following years: the Annex Building along the north side of the quadrangle in 1808-1809; the Long Storehouse, which is now used to house large numbers of gun stock blanks, lumber and other supplies, in 1846-1847; the garage building which was formerly the Forge Shop, in 1863; the Main Arsenal, a fine three-story building of imposing appearance on the west side of the quadrangle, in 1846-1850. The various quarters for officers and non-commissioned officers were erected on the following dates: Quarters No. 1, occupied by the Commanding Officer, in 1844-1845; Quarters No. 2, in 1894; Quarters No. 3, in 1898; Quarters No. 4 in 1836; Quarters No. 5 and No. 6, in 1870. Quarters No. 7 is the rear portion of the quarters formerly occupied by the Ordnance Storekeeper. It was built in 1833. The main portion of this building is now the Hospital Annex. Quarters No. 8 and No. 9 were built in 1836. The present Hospital building was erected in 1836 and was originally the quarters of the Master Armorer. These buildings in Armory Square constituted the main Hill Shop Plant of the Armory until the completion of the construction in 1887-1892 of the group of modern fire-proof buildings in Federal Square known at the time as the New Hill Shops. This group of buildings includes the Milling Shop, the Machine Shop and the Woodworking Shop. In 1902 additional machinery and equipment to the value of $113,438.60 was purchased and installed in these buildings to provide for an output of 400 arms a day of 8 hours or 1,000 arms a day of 24 hours. No further additions to or material changes in the Hill Shops plant were made thereafter until the period of the World War. During that period the new Experimental Building in Armory Square and the new Metallurgical and Chemical Laboratory in Federal Square were erected and equipped.

Commanding Officer's Quarters, Springfield Armory.

THE development of the plant at the Water Shops began soon after the passage of the Act of Congress of April 2, 1794, and has kept pace with that at the Hill Shops. By 1817 there were three shops in operation on Mill River known as the Upper, Middle and Lower Water Shops. The records of the Armory afford no very precise or authentic information as to the dates of erection or cost of the buildings at these early plants. The buildings were not of permanent construction and nothing now remains of any of them. Until 1844 these three plants furnished all the

Water Shops, Springfield Armory.

mechanical power necessary for operating forges and smelting furnaces and for driving the machinery employed in the manufacture of fire arms at the Armory. In 1857 the Middle and Lower Shops were consolidated with the Upper Shops and a nnumber of important additions were made to the plant between that date and 1863. At the same time in 1857 the height of the dam was increased and the bed of the stream below the dam was lowered so as to give a total head of water of 35 feet, greatly improving the power facilities of the plant.

No further material changes in the Water Shops plant were made until after the Spanish-American War. The experience of that war emphasized the fact that the capacity of the Armory to produce rifles was limited by the capacity of the Water Shops, and that the buildings and the equipment of the latter plant would have to be considerably enlarged to provide for an adequate output and to keep pace with the facilities of the New Hill Shops plant. In 1900 an Act of Congress was approved which appropriated the necessary funds for the enlargement of the buildings at the Water Shops and the purchase and installation of additional machinery for both the Water Shops and the Hill Shops to provide for an output of 400 arms a day of 8 hours, or 1,000 arms a day of 24 hours. These additions to the plant were completed in 1902 at a total cost of $300,000.00. A new hydroelectric turbo-generator of 500 horse-power capacity was installed to replace the old, inadequate water wheel. This installation has more than sufficient capacity to supply power to the Water Shops for peace-time operations except during periods of draught.

THE manufacture of small arms began at the Armory in 1795, the year following the passage of the Act of Congress establishing it, and has never ceased since that date. In that year 245 muskets, the smallest number produced in one year, were made at the Armory. There were 40 employees on the payroll, and the total disbursements were $4,495.75. The early development of the institution as a manufacturing establishment seems to have been considerably retarded by difficulty in obtaining raw materials, such as walnut wood, coal and iron, all of which had to be transported a considerable distance, and difficulty in obtaining necessary operating funds. The period of greatest activity at the Armory prior to the entrance of the United States into the World War was that embraced by the Civil War. During the four years from 1861 to 1865 more than 800,000 muskets were manufactured. In the year 1864 alone the output of muskets was 276,200, the total disbursements were $4,247,998.84 and there were 2,992 employees on the payroll.

It was during the year 1918 that the manufacturing activities of the Armory reached the highest point in its existence. Practically all efforts were concentrated on the production of the U. S. Rifle, caliber .30 M 1903, and parts and appendages therefor. Starting in June, 1917, with an average daily production of 175 rifles, this figure was increased month by month until by November, 1918, the average daily production of rifles with their spare parts and appendages, assembled, packed and turned into store for shipment, reached the enormous total of 1,500. The largest number of employees on the payroll was 5,381 in November, 1918. The total disbursements for 1918 amounted to $10,510,554.51.

DURING the 134 years of the existence of the Armory manufacturing operations have continued without interruption, and muskets, carbines and rifles have been produced under some 34 different models. The French Charlesville smooth-bore musket of the model of 1763, caliber .69, was the type first adopted. This model was manufactured at the Armory with practically no modifications until about 1842, when a percussion firing mechanism was substituted for the flint lock theretofore in use.

The year 1855 saw the final adoption for the Army and inauguration of manufacture at the Armory of the first rifled musket. At the same time the caliber was reduced from .69-inch to .58-inch and an elongated bullet was introduced to replace the round ball used in the smooth-bore weapon. This model with only slight modifications was manufactured in large numbers from 1861 to 1865, and

Main Shop Buildings, Hill Shops, Federal Square, Springfield Armory.

used by our soldiers throughout the entire period of the Civil War.

In 1866, following closely upon the termination of the war, progress in the design of the military rifle again moved on apace. In this year the breech-loading rifle was introduced. The first of these were converted from the caliber .58 muzzle-loading rifles following the design of E. S. Allin. Thereafter improvements were continually made, resulting in 1873 in the adoption for the Army of the caliber .45-inch single shot weapon known at the time as the Springfield Rifle. This weapon remained the standard military rifle of our Army for practically the next two decades. Efforts looking toward the further improvement of the rifle, especially in the direction of increased rapidity of fire, were, however, unremitting throughout this period. These efforts, after a long series of experiments, resulted in 1892 in the displacement of the caliber .45 Springfield Rifle, and the adoption of the bolt-action caliber .30 magazine rifle known as the Kragg-Jörgensen.

Further experimentation and test led to the adoption in 1903 of the U. S. Rifle, caliber .30 Model of 1903, which is the arm at present used in the Army, the Navy, the Marine Corps, the National Guard and all other contingents of the Army of the United States. So well was it originally designed that only minor modifications have been found necessary in the twenty-five years since this rifle was adopted.

The principal peace-time activities of the Springfield Armory are those connected with the manufacture of the U. S. Rifle, caliber .30 M 1903 and its several modifications, the U. S. Rifle, caliber .22 M 1922 MI, together with the spare parts and appendages for these arms, the repair and maintenance of these arms and of pistols, revolvers, automatic rifles, machine guns, tripods, etc., and the manufacture of spare parts for the latter. In addition the Springfield Armory carries on a large amount of experimental work connected with the improvement of existing types of small arms, machine guns, machine gun mounts, tripods, etc., and the development of new designs of this matériel, and also in connection with the improvement of methods of manufacture.

AS elsewhere stated in this article Springfield Armory since it was established has consisted of two main plants, the Hill Shops and the Water Shops. These plants are about one mile apart and are connected by city streets. The Headquarters Building, officers' quarters, barracks, hospital and other buildings connected with the military post, also the main storehouses are at the Hill Shops in Armory Square. The shops pertaining to the Hill Shops plant are, at this time, for the most part in standby condition, the major portion of the manufacturing activities having been moved to the Water Shops several years ago for reasons of economy, so as to utilize fully the water power available at that plant. The principal manufacturing operations done at the Hill Shops are those connected with making the gun stocks, parkerizing, browning and heat treating of metal parts, assembling components and testing, targeting and otherwise inspecting completed arms.

THE part played by Springfield Armory during the World War was of tremendous importance to the Army and to the country, and it would undoubtedly become so again under similar conditions. The present mobilization plan of the Ordnance Department contemplates in the event of a major emergency that Springfield Armory manufacture the major part of all the rifles issued to our armed forces and that the production of these rifles begin without delay after the emergency is declared.

To carry out these requirements the plan of this Armory has been worked out so as to cover all the details connected with the rearrangement of the machinery now installed, the installation of machinery on hand and in storage, recruitment and training of personnel, military and civilian, and the procurement of necessary materials so as to begin production in the shortest possible time and insure an uninterrupted flow of work.

This plan also provides for the establishment at the Armory of training schools for commissioned and civilian employees to be used as inspectors, sub-inspectors and production assistants at small arms plants in the several Ordnance Districts, and for the training of enlisted men as specialists in the maintenance of small arms in the field.

Muskets of the Revolutionary War Period, Civil War Period, and Present Service Rifle—Semiautomatic not yet adopted.

1. Musket, French, Model 1763, St. Etienne manufacture. 2. Musket, British Brown Bess, captured from Burgoyne's 20th Regiment at Saratoga, 1777. 3. Springfield Rifle, Cal. .45, Model 1873. 4. Ward-Burton Magazine Rifle, Cal. .45, submitted to Board of 1872. 5. U. S. Rifle, Cal. .30 M. 1903; the Springfield of today. 6. A self-loading shoulder arm under development for several years should appear soon.

Types of Rifles Now Manufactured at Springfield Armory.

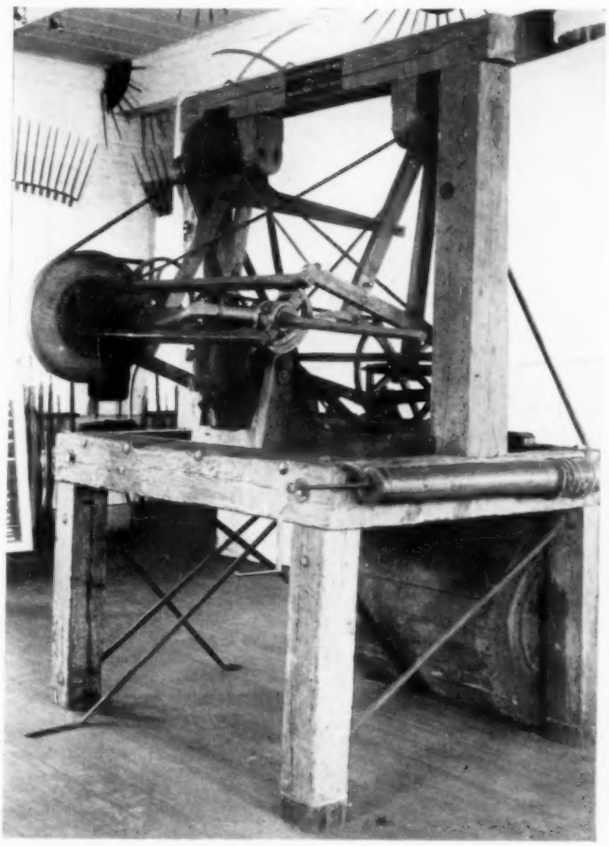
1. U. S. Rifle, Cal. 22, Model 1922, M1. 2. U. S. Rifle, Cal. .30, Model 1903, Sporting. 3. U. S. Rifle, Cal. .30, Model 1903, National Match. 4. U. S. Rifle, Cal. 30, Model 1903, The Service Springfield. 5. U. S. Rifle, Cal. .30, Model 1903, Heavy Barrel. 6. U. S. Rifle, Cal. .30, Model 1903, International.

Manufacturing at Springfield Armory

By Lieut. Col. John H. Read, Jr.,* Ord. Dept., U. S. A.

WHEN the question of the post-World War status of small arms is being given consideration, it is not unusual to hear it surmised, so rare is true knowledge of actual conditions, that, now the war is over, the arsenals filled with cannon, rifles and munitions of all kinds, there can be but little going on at the Springfield Armory except in connection with storage and issue.

As a matter of history, not since work began at the National Armory, as it was then called in 1795, with 40 men, has there been a cessation of manufacturing operations. A short sketch of what the 350 men now employed are doing to "keep alive the art of gunmaking" may be of interest. "Keeping the art alive" implies something more than training new men to do well those things in which their fathers were skilled. Were this the sole requirement we would still be making the muzzle loading flintlock of the Revolutionary period; turning out walnut gun stocks by hand at the rate of one per man per day of 10 hours, the best production obtainable until Thomas Blanchard in 1822 invented a stock turning lathe; and making barrels by "forming bars of English iron into hollow cylinders and then welding," a process in vogue during the Civil War, three men forming 450 in 10 hours.

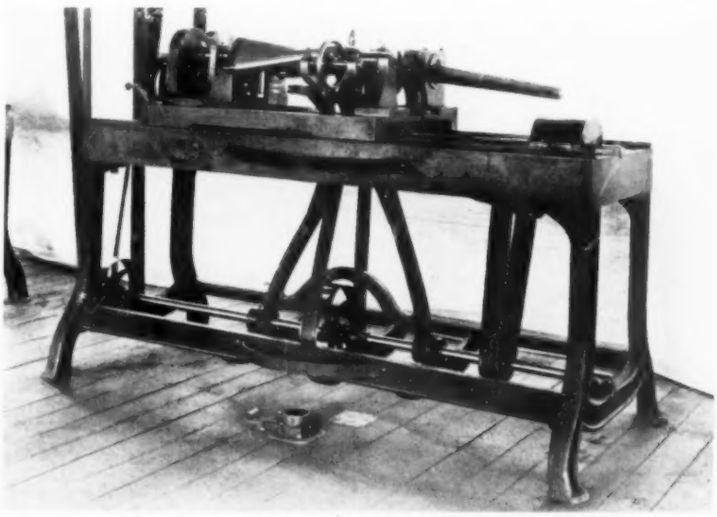


Stock Turning Lathe Invented by Thomas Blanchard, 1822.

Merely keeping abreast of the art is an unambitious program and not in accordance with Yankee tradition or characteristic of American genius endeavoring always to contrive weapons of war superior to those any potential enemy can bring against us.

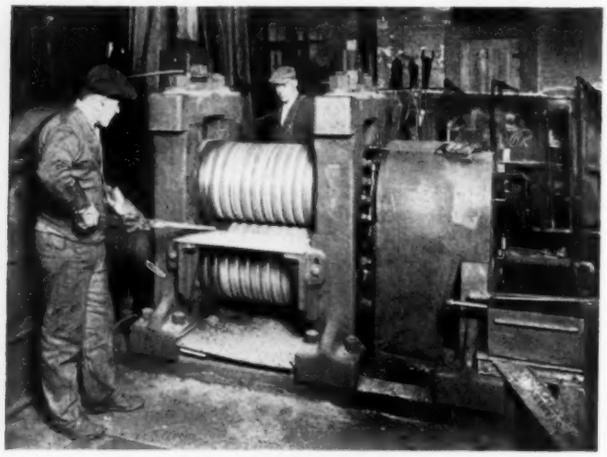
Improvement of designs, creation of new types—involving continual research and experiment—are required to meet the innnovations and more and more exacting demands of modern warfare, as exemplified by the advances from the muzzle loader to the breech loader, from the single loader to the magazine type, from the self-loading to the full automatic, from arms for troops to armament for armored cars, tanks and aircraft, all demanding perfect interchangeability and complete automaticity.

A GREAT retarding factor to progress is the difficulty in obtaining appropriations for research and experimental work, the value thereof, judged by tangible results obtained, being not always readily apprehensible to the average mind nor capable of being estimated with accuracy by designers and engineers. Another obstacle to the introduction of new types is the high cost of making drawings, designing and fabricating the necessary gages, tools, dies, jigs and fixtures for the manufacture of interchangeable components on a large scale. Therefore, the selection of a type upon which considerable funds are to be expended, assumes a position of first importance. It is never a simple problem and seldom is the adopted model an ideal type, but rather a compromise with concessions to economy or to the demands of a pressing need in an emergency.



Stock Turning Lathe, Springfield Armory, 1928.

*Officer in Charge of Shops, Manufacturing Department, Springfield Armory.



Barrel Operation B.
Rolling from billet. Size of stock, 1.4-inch diameter, 12 inches long, rolled out to 25 inches.

When in 1795 the French musket of 1763, St. Etienne and Charleville manufacture, was taken by us as a model instead of the British Brown Bess with which we were armed in Colonial days and presumably more familiar, a wise choice was made. It was more accurate at long range and was stronger, the stock being secured by bands instead of pins.

From a retrospective point of view the same can not be said of the choice of a breech-loading system for rifles and carbines made by the Board of Officers appointed in pursuance of the Act of Congress, approved June 6, 1872, when it recommended the continuation of the Springfield system, modified to caliber .45, which came out as Model 1873, instead of selecting one of the very practical magazine arms demonstrated before it of both American and foreign design. The Board expressed the opinion that "the adoption of magazine guns for the military service of all nations was only a question of time," and, was so impressed with the merits of the Ward-Burton system, that, though unwilling to recommend its adoption in face of unanimous reports from the Army against the Ward-Burton single loader, it took occasion to recommend that a small number be made for field trial. A proviso in the appropriation bill for the fiscal year, 1873, prohibited the manufacture of guns for trial, and, so nothing was done—none were made. The magazine under the barrel of the model before the Board holds eight rounds.

At this distance of time it is now clear that it would have been wise to have expended the entire appropriation, $150,000, on the development of a military magazine rifle, instead of choosing for manufacture the Springfield, modified and improved though it was, soon earning a most enviable reputation, but delaying the adoption of a magazine rifle for 20 years.

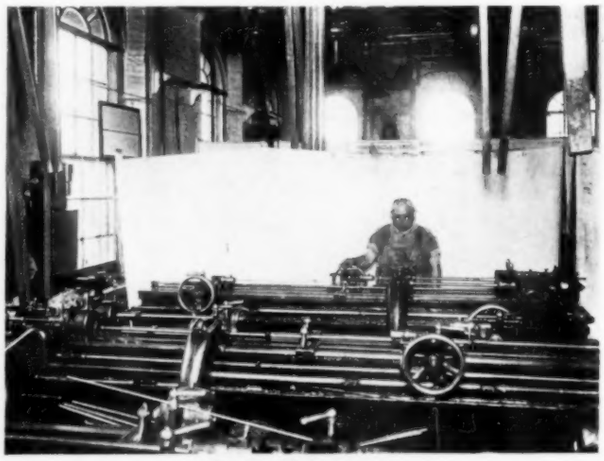
THE Manufacturing Department at Springfield Armory comprises the usual divisions of a modern machine shop organization, each in charge of a qualified and experienced foreman, all under the immediate and personal supervision of a general foreman who reports to an officer designated by the Commanding Officer as Officer in Charge of Shops. The divisions are Planning, Forging and Pressing, Heat Treating, Milling Shop, Barrel Shop, Bolt, Guard and Automatic Shop, Machine Shop, Parkerizing & Browning, Case Hardening, Laboratory, Power & Plant Maintenance, Assembly Shop, Proof-firing & Targeting. An Inspection Division, organized as an independent unit in charge of an officer, reports direct to the Commanding Officer, thus assuring the maintenance of the quality of the product and the standards prescribed by the Chief of Ordnance. Inspectors perform many of the functions of a shop-planning section.

The quality and interchangeability of components of the various arms manufactured is maintained by rigid adherence to tolerances by the use of numerous limit, special purpose and functional gages, 1,263 being employed for the service rifle alone. Shop inspection of each operation as performed insures early elimination of defective pieces saving the expenditure of time and labor of further operations. The system of gaging while not the most modern gives perfect satisfaction in the hands of inspectors trained at the Armory. Worn out gages are replaced by new ones embodying the latest principles of gage engineering. All working gages are checked at least weekly.

The tolerances on special work, like National Match rifles, Sporters, and barrels for taking pressures or testing the accuracy of ammunition, are very small. For example, the dimensions on a National Match barrel are: bore, .3000-inch to .3005-inch; grooves, .3080-inch to .3085-inch, with a proviso that in any barrel the variation shall not exceed .301, thus insuring an exceedingly smooth surface free from roughness and pockets.

The machinery and tool equipment for small arms manufacture follow commercial practice, differing in this respect to a certain extent from the methods of turning out other items of Ordnance material. Rifle barrels require special drilling, reaming and rifling machines.

Since the World War it has been found necessary in the interest of economy to concentrate all machine operations except wood-working at the Water Shops in order that the abundant water power there may be utilized. The machinery installed provides for a maximum output of 75 rifles per 8 hour day and the manufacture of replacement components for pistols, automatic rifles and machine guns.



Barrel Operation 5.
Drilling bore to .293-inch.

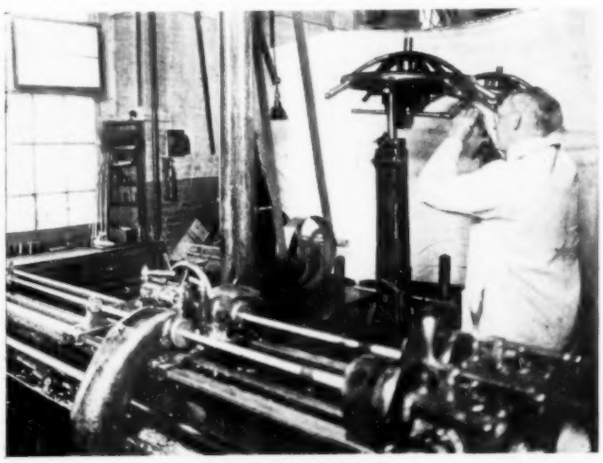
NOTWITHSTANDING the employment of modern machinery, improved methods and complete sets of working gages frequently checked by comparison with master gages, a large share of credit for the smooth working action and the fine shooting qualities of the Springfield Rifle must be given to the men, who, devoting the best years of their lives to its production, develop a high degree of skill and an inimitable technique. Proud of its reputation at home and abroad, zealous of maintaining its good name, they take a personal pride in putting their best into their work, passing along from generation to generation the best traditions of the art. At least one family has had a representative at the Armory since 1809. Many of the men, expert shots themselves, follow with deep interest and understanding the fortunes of our teams at the National and International Matches and are keen to grasp suggestions for improvement and thus keep themselves in the forefront of the craft.

In some classes the labor turn-over has been heavy, especially in the lower ratings. However, tool makers have had ample opportunity to exercise their talents on experimental models, a number of projects of this nature having been undertaken and carried to completion during the year. The manufacture of gages for replacement and for new work, such as the caliber .50 machine gun barrel, has been sufficient to give training to gage makers in fine precision work.

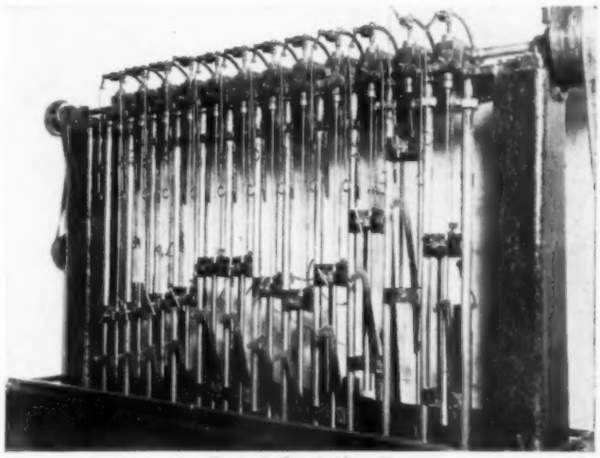
AT PRESENT no service rifles are being manufactured. However, the large number of unserviceable rifles on hand requiring parts for replacement, the manufacture of large numbers of the caliber .22 rifle for gallery practice, the manufacture of the caliber .30 sporting type for sale, together with considerable repair work, have been more than sufficient to keep the force of 350 men busily employed during the entire year. For replacement on one component alone, the barrel, an approved project calls for the manufacture of 225 per day.

The quantities of the principal items manufactured at Springfield Armory during the fiscal year ending June 30, 1928, are as follows:

Rifles, U. S. Caliber .22, Model 1922, M1	1,906
Rifles, U. S. Caliber .30, Model 1903, National Match	212
Rifles, U. S. Caliber .30, Model 1903, Sporting Type	320
Rifles, Semiautomatic, Caliber .276, Experimental	20
Rifles, Semiautomatic, Caliber .30, Experimental	20



Barrel Operation 13.
Straightening bore, line system.



Barrel Operation 7.
Reaming bore—.295-inch diameter.

Aiming Devices	3,500
Ammunition Boxes, Browning Machine Gun, Cal. .50, M1921	140
Barrels, Automatic Pistol, Cal. .45, Model 1911	16,985
Barrels, Pressure, Caliber .30	189
Barrels, Pressure, Caliber .50	10
Barrels, U. S. Caliber .30, National Match	2,000
Barrels, U. S. Caliber .30, Model 1903 (Service Rifle)	50,000
Bolts for U. S. Rifle, Caliber .30, M1903	10,000
Chests, Accessory, Browning Machine Gun, Model 1917	800
Gas Pistons and Cylinders, Browning Machine Rifle, M1918	500
Hand Guards for U. S. Rifle, Caliber .30, M1903	120,000
Receivers for U. S. Rifle, Caliber .30, M1903	10,000
Parts for Belt Filling Machine, Model 1917	12,921
Parts for Browning Machine Gun, Caliber .30, M1917	30,969
Parts for Rifle, Caliber .22, Model 1922, M1	25,730
Parts for Rifle, Caliber .30, Model 1903	350,614

THE shop standard of manufacture and acceptance of that component of the service rifle upon which accuracy depends, the barrel, is higher today than ever before, due in part to experience gained in meeting the exacting specifications for the barrel of the National Match rifle. The special care given the latter in selection of stock, in adjustment of machines, in dressing of tools, and in gaging all operations with final star-gaging, is reflected in the attitude which both workman and inspector take toward the former. What in previous years was "viewed and passed" (stamped V P), as acceptable to the eye, is ruthlessly "rejected" as "rough" under the glass of the inspector of today. Whereas, except as to permissible tolerances and character of finish, the 113 operations are identical, the two barrels when completed being interchangeable.

The steel used is the standard high manganese barrel steel, War Department Specifications No. 1350, in bars 1.4-inch round, heat treated to give the required physical characteristics, namely:

Tensile strength	110,000 lbs. per sq. in.
Elastic limit	75,000 lbs. per sq. in.
Elongation	20 per cent.
Contraction of area	50 per cent.

The overall length of the barrel is 24.006 inches. The length of chamber is 2.3716 inches; travel of bullet in bore 21.697 inches; the exterior diameter at breech is 1.14 inches; at muzzle, .619 inches. The twist is uniform, right hand, one turn in ten inches. The weight of the barrel with rear sight base and front sight fixed stud is three pounds.

After the barrel blank comes from the drop hammer and is heat treated, it passes into the Barrel Shop located at the Water Shops, through the operations listed below and in the order named therein, the changes in sequence well illustrating progress in manufacture through the years since the rifle was adopted in 1903. Old processes dropped, newer methods instituted and regrouping of operations have been made in the interest of economy and to facilitate inspection.

The most interesting operations, perhaps because they are the most difficult and the most important, are the drilling, the reaming, the rifling and the chambering operations, all requiring special machinery, special tools and special gages.

The cutting oil used is pure lard oil, which on the barrel drilling machines is forced through the one-lip drill point at a pressure of 700 lbs., while the barrel, not the drill, revolves at 2150 r. p. m. The finish reaming, from .298-inch to .300-inch, by pulling a properly honed seven-toothed scrape reamer through the bore, actually scrapes out the last thousandth of the metal and leaves the surface free from pockets and glass smooth. As for the rifling, none but an expert craftsman can quill and hone the edge of a scrape rifling cutter to its proper shape and dimensions, nor fit it into the eye of the rifling head at the required angle and give to the actuating wedge that nice sliding fit deemed so desirable. Chambering to finished dimensions is also a most exacting performance, requiring seven multi-toothed reamers and fourteen special gages, diameter, depth and taper.

Barrel Operation 25.
Straightening bore, ring system.

The cutting compound designated, as used in many of the other operations as a lubricant and refrigerant, is made as follows: Take ¼ lb. soda ash and dissolve in one quart hot water; add 15 gals. water; mix ½ gal. soluble oil and ½ gal. lard oil; stir the mixture into the soda solution.

U. S. Rifle, Caliber .30, M1903—Barrel Operations in Detail

Operation O.—*Cutting billets from bar stock.*

Machine used: Hilles & Jones Stock Shears No. 2, belt driven. Number of operators per machine: One. Cutting tools: Two carbon steel knives with semi-circular edges which cut bar without flattening. Cuts: One per billet. Bar rests on shelf on shears and is hand fed. Size of stock—1.4-inch diameter, 12 feet long. Stop on shears regulates length, 12½ to 12¾ inches, depending on condition of rolls. Production: 240 per hour.

Operation A.—*Heating.*

Equipment used: Gilbert & Barker oil furnaces, size three feet square; air pressure 15 to 18 pounds. Pyrometer: Wilson & Maucleu. Temperature depending on class of steel rolled, War Department Specification 1350 requiring about 1400° F. Production: Two men, 40 per hour.

Operations B and C.—*Rolling from billet and catching.*

Machine used: A modified type of Farrel Foundry & Machine Co.'s. Rolls are made at the Armory 18 inches diameter by 31 inches long with 11 grooves. Number of operators: Two designated as roller and catcher. The roller takes billets from furnace and passes them between the rolls, the catcher passes them back over the rolls. The barrel after passing through the last groove is 25 to 25½ inches long. Gages: Snap. Production: 40 per hour.

Operation D.—*Straightening under drop hammer.*

Equipment used: Bement 400-pound drop hammer. The catcher in Operation C straightens the barrel on same heat as it comes from the rolls using not to exceed six blows. Production: Same as barrel rolling.

Operation DK.—*Inspection.*

Visual inspection of work of Operations B and C is all that is necessary to cull out deformed barrels. With an expert roller the loss is practically nil. Barrels are placed in truck boxes of boiler iron 16 inches by 47 inches by 16 inches mounted on three 8-inch wheels and moved to Operation E.

Operation E.—*Heat treating.*

Heat to 1600° F. two hours and air cool. Heat to 1550° F. and quench in oil—Houghton's Soluble No. 2. Draw at 1100° to 1200° F. one and a half to two hours to produre required physical characteristics.

Operation EK.—*Inspection.*

Equipment used: Brinell hardness testing machine and tensile testing machine. Brinell range for War Department Specification 1350 stock—3.7 to 4.1, giving hardness Numbers 217 to 269. Inspection for seams and for straightness is also made at this time.

Operation 6.—*Milling butt and sawing to working length for turning.*

Machine used: Becker Miller, No. 25. Number of machines per operator: Two per 225 output. Run in connection with Operations 2 and 1. Work holding device: Double end fixture, two barrel. Tool holding device: Arbor 1¼ inches. Cutting tools: 1 side mill 7 inches; circular saw 6½ inches. Number of cuts: Two butt, two muzzle. Cut data: Arbor speed 32 r. p. m. Feed ⅝ inch. Cutting oil or compound: Compound. Average life of tool between grindings: 1,000 barrels. Gages: Length 24.125 inches. Production: Four machines 8 hours, 1,024 barrels.

OPERATION 6A.—*Stamping stock mark on end of butt.*

Barrels are placed in barrel rack, butt up. Tools used: 3/16-inch steel stamp and steel hammer. Production: 300 per hour.

OPERATION 2.—*Centering both ends.*

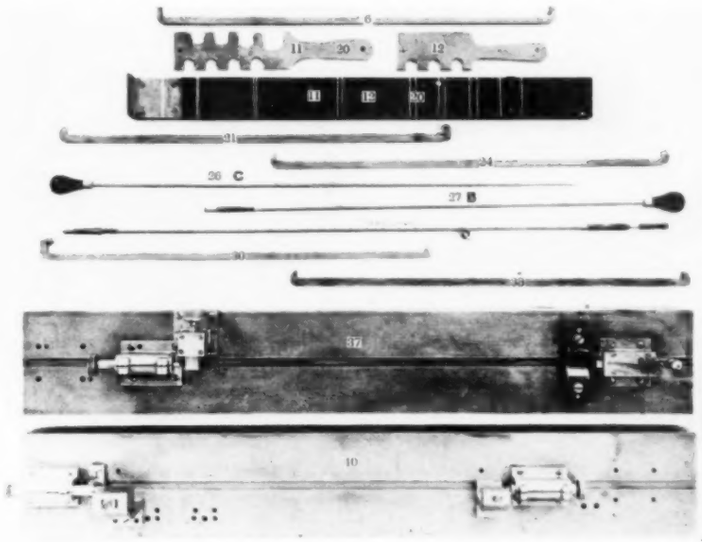
Machine used: Pratt & Whitney two-spindle centering machine. Number of machines per operator: One. Work holding device: Screw vise with V jaws. Tool holding device: Drill chuck. Cutting tool: No. 31, highspeed twist drill and countersink. Number of cuts: two on butt, and two on muzzle. Cut data: Spindle speed 400 r. p. m. Cutting oil or compound: Machine oil. Average life of tool between grindings: 300 barrels. Gages: None. Production: 110 per hour.

OPERATION 1.—*Straightening outside.*

Machine used: Barrel is revolved by hand on bench centers and high spots noted. Barrel is then straightened by steel hammer on straightening block. Gages: None. 100 per cent. require straightening. Production: 100 per hour.

OPERATION 1K.—*Inspection.*

Operations 6, 6A, 2 and 1 are inspected as a group. The inspector revolves the barrel on centers to observe the degree of straightness. He notes that stock mark is on barrel and whether both ends have a clear cut. He observes whether centering is properly done and applies length gage 24.125 inches.



Some of the Barrel Gages Used in the Manufacture of the Springfield Rifle.

OPERATION 8.—*Spotting muzzle.*

Machine used: Cowdrey turning lathe. Number of machines per operator: Two. Work holding device: Driven with dog on centers. Cutting tool: ½ inch square high speed steel in regular tool holder. 300 r. p. m. Number of cuts: One. Cutting oil: Compound. Average life of tool between grindings: 100 barrels. Gages: Ring .761 inch. Production: 100 per hour. This spotting is about 2 inches long to fit drill bushing (muzzle), .761 diameter.

OPERATION 8½.—*Spot grinding for back rest.*

Machine used: Pratt & Whitney spot grinder. Number of machines per operator: One. Work holding devices: Butt and muzzle centers. Work driven with dog on centers. Cutting tool: Aiundum wheel, 18 by 1 by 5 inches. Number of cuts: One, width of wheel near center of barrel for Operation 9¼. Spindle speed: 1050 r. p. m. Feed: Hand. Cutting oil: Economy grinding lubricant. Average life of wheel: 15,000 barrels. Gages: None. Production: 63 per hour.

OPERATION 8½K.—*Inspection of Operation 8½.*

Visual only. On Operation 8 two gages are required, one fixed limit gage and one ring gage .761-inch.

OPERATION 9¼.—*Turning outside rough.*

Machine used: Reed & Prentice multiple tool turning lathe. Number of machines per operator: Two. Run in connection with Operation 9½. Work holding device: Driven with dog on centers. Tool holding device: Regular tool holder supplied with machine. Cutting tools: Five turning tools, high speed steel, 1 inch by ½ inch. Number of cuts: One. Speed 270 r. p. m. Feed: 4 inches per minute. Cutting oil: None. Run dry. Average life of tools between grindings: 25 barrels. Production 25 barrels per hour per machine. Gages: Snap.

OPEPRATION 9½.—*Straightening outside.*

Repetition of Operation 1. Production: 125 per hour.

OPERATION 9½K.—*Inspection.*

This inspection covers Operations 9¼ and 9½. In addition a close examination for seams is made under magnifying glass.

Gages: One limit gage for size of muzzle in rear of muzzle spotting; one for butt. A slide gage with six limit dimensions is used for testing size of barrel at various points.

OPERATION 5.—*Drilling bore, .293-inch diameter.*

Machine used: Pratt & Whitney horizontal drilling machine, two spindle. Number of machines per operator: Six. Work holding device: Held by friction in taper chuck at butt end; held in bushing at muzzle end; bushing to guide drill point. Tool holding device: Drill shank soldered into spool, spool held by set screw. Cutting tool: One-lip drill, Rex A. A. high speed steel. Number of cuts: One. Cut data: Barrel turns 2150 r. p. m.; feed, 1 inch. Cutting oil: Pure lard oil forced by Dean pump at 700 pounds pressure through drill point, returns through pipe and screen to large tank and is repumped back to machine. Oil from chips is extracted by separator and returned to oil tank. Average life of tool between grindings: 1.5. Gages: Plug .293. Production: 22 per hour per machine.

OPERATION 7.—*Reaming bore, .295-inch diameter.*

Machine used: Baush 12 spindle reaming machine. Number of machines per operator: One. Work holding devices: One dog per spindle hold one end of barrel, the other floats. Tool holding device: Five-tooth cutting reamer. Number of cuts: One per spindle. Speed: 190 r. p. m. Feed: As fast as barrel is reamed, regulated by counterweights. Cutting oil: Lard oil. Average life of tool between grindings: 800 barrels. Gages: Plug gage, .295 diameter. Production: 1,000 per 8 hours.

OPERATION 7BK.—*Inspection.*

This inspection covers Operations 5, 7, 7W and 7B.

A visual inspection is made of the barrel for rings and roughness. A plug gage .295-inch diameter is used to test dimensions of bore. On the butt end a button slightly larger than rear base seat is used to determine if barrel drilling has run out too much to make a clear base seat.

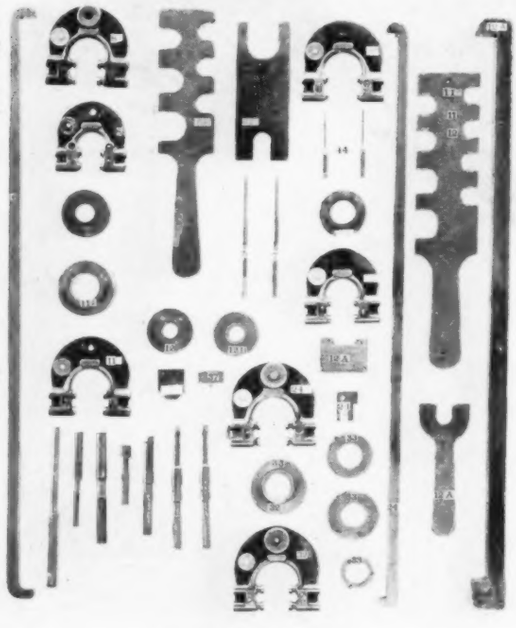
OPERATION 19¾.—*Countersink muzzle and butt ends for grinding machine.*

Machine used: Woodward & Rogers two-spindle drill press. Number of machines per operator: One. Work held by hand. Tool holding device: Drill chuck. Cutting tool: Worn out chamber reamer is used. Number of cuts: One. Speed: 700 r. p. m. Hand feed. Cutting oil: None. Average life of tool: 5,000 barrels. Production: 160 per hour. Gages: Depth only.

OPERATION 19½.—*Turning butt to size for grinding.*

Machine used: Cowdrey turning lathe. Number of machines per operator: Three. Work driven with dog on centers. Tool held by regular tool holder. Cutting tool:

½ inch square high speed steel. Number of cuts: One. Speed: 330 r. p. m. Feed: 1¾ inch. Cutting oil: Compound. Average life of tool between grindings: 100 barrels. Production 25 per hour per machine. Gages: Snap, 1.148 inch-1.152 inch.



Barrel, Caliber .30.
Gages for checking operations, as numbered, on the barrel of the Springfield Rifle.

Operation 9A.—*Stamping stock mark on muzzle spotting.*

A Babbitt block shaped to spotting on muzzle and holding five barrels at one time is used. Cutting tools: 3/16-inch steel stamps and steel hammer. Production: 200 per hour.

Operation 19.—*Chambering to remove stock to working size.*

Machine used: Pratt & Whitney turret machine, 8 spindle. Number of machines per operator: One. Work holding device: Chuck to fit spotting on muzzle (.761 inch). Tool holding device: Special tool holder made to fit turret spindle. Cutting tools: 1 face mill; 5 cutting reamers; 1 counterbore; 1 countersink. Number of cuts: Eight. Speed: 190 r. p. m. Hand feed. Cutting oil: Lard oil. Average life between grindings: 150. Production: 40 barrels per hour. Gages: Plug for depth and diameter. Oil is pumped through bore of barrel from muzzle to butt onto tools. Stops for depths are attached over reamers to tool holders.

Operation 19BK.—*Inspection.*

This inspection includes Operations 19, 19W and 19B.

This is the rough or working chamber. The inspector uses depth and diameter chamber gages and also mirror or reflector to observe condition of walls of chamber.

Operation 13.—*Straightening bore, line system.*

Machine used: Pratt & Whitney barrel straightening jack. Number of machines per operator: One. Work holding device: Jaws to fit shape of barrel. The operator with barrel in jack sights through bore at ground glass in window with narrow horizontal line across center at a distance of about 12 feet. Each side of the barrel reflects the horizontal line. If they are parallel the bore is straight; if not parallel, note is taken of the bend or bends which are then taken out by hand power applied to the jack. Production: 63 per hour.

Operation 11¼.—*Grinding butt end for rear sight fixed base.*

Machine used: Norton cylindrical grinder 10 by 36 inches. Number of machines per operator: One. Work holding devices: Butt and muzzle centers. Tool holding device: Driven by dog on centers. Cutting tool: Alundum wheel 18 by 12 by 5 inches, Grade 24 CK. Number of cuts: One. Speed: 140 r. p. m. Hand feed. Economy grinding lubricant is used. Average life of tool between grindings: 100 barrels. Gages: Snap and ring 1.140-1.141. Production: 100 per hour. Tariff: .00637. There is a fixture attachment to dress wheel with black diamond in holder.

Operation 11¾.—*Grinding radius for rear sight fixed base.*

Machine used: Norton cylindrical grinder, 10 by 36 inches. Number of machines per operator: One. Work held by butt and muzzle centers and driven by dog on centers. Wheel used: Alundum 18 by 3 by 5 inches, Grade 3846 M at 1350 r. p. m. Speed of work: 140 r. p. m. Hand feed. Cutting compound: Economy grinding lubricant. A fixture and form is used to give wheel the shape of radius. Dressing of wheel required after each 100 barrels. Gages: Snap and ring .9566-.9576. Production: 75 per hour.

Operation 11½.—*Grinding section from location of upper band to front sight fixed stud.*

Machine used: Cylindrical grinder 10 by 36 inches. One machine per operator. Work held by butt and muzzle centers and driven with dog on centers. Wheel used: Alundum 20 by 5 by 12½ inches, Grade 3846, at 1350 r. p. m. Number of cuts: One. Speed: 140 r. p. m. Cutting compound: Economy grinding lubricant. Wheel is dressed after each 100 barrels. Gages: Slide gage and gage board. Production: 60 per hour.

Operation 11.—*Turning outside to finish.*

Machine used: Cowdrey single tool turning lathe, 16 inches. Number of machines per operator: Eight. Work is driven with dog on centers. Cutting tool: ½-inch square high speed steel, held in regular tool holder. Number of cuts: One. Speed: 330 r. p. m. Feed: 1¾ inch. Cutting oil: Compound. Average life of tool: 50 barrels. Gages: Ring, snap and gage board. Production: Eight barrels per machine per hour.

Operation 12A.—*Shouldering for front sight fixed stud.*

Machine used: Single tool turning lathe, 13 inches, Prentice. One machine per operator. Work driven with dog on centers. Cutting tool: A special made cutter for skiving operation held in regular tool holder. Number of cuts: One. Speed: 512 r. p. m. Feed: Hand. Cutting oil: Lard. Average life of tool between grinds: 200 barrels. Gages: Snap. Production: 70 per hour.

Operation 24.—*Face milling muzzle to working length.*

Machine used: J. G. Blount Co. speed lathe. One machine per operator. Work is held on pilot of end mill and on tail stock center and dog. Tool is held in taper of spindle hole of lathe. Cutting tool: End mill with pilot. Number of cuts: One. Speed: 560 r. p. m. Hand feed. Cutting oil: Compound. Average life of tool between grinds: 200. Gages: Length gage. Production: 100 per hour.

Operation 12B.—*Turning muzzle for bayonet guard.*

Machine used: Single tool turning lathe, 13 inches, Prentice Bros. Number of machines per operator. One. Work is driven with dog on centers. Cutting tool: High speed steel, 11/32 inch by ¾ inch, held in regular tool holder. Number of cuts: One. Cutting oil: Lard. Average life of tool: 800. Gages: Ring. Production: 70 per hour.

Operation 12.—*Filing outside to gage.*

Machine used: Henry Prentice Co's. speed lathe. Number of machines per operator: One. Work is driven with dog on centers. Cutting tools: 12-inch mill bastard file, 6-inch pillar. Number of cuts: Two. Files last 1,000 barrels. Speed: 1800 r. p. m. Gages: Slide gage with spacer attached to machine. Production: 53 per hour.

Operation 24C.—*Turning tenon on butt.*

Machine used: Prentice Bros. single tool turning lathe, 13 inches. Number of machines per operator: Two. Work is driven with dog on centers. Cutting tools: Worn out tools from Operation 9¼ are used. Number of cuts: One. Speed: 290 r. p. m. Feed: 1⅞ inches per minute. Run dry. Average life of tools: 200. Gages: Snap, 1.041-1.042-inch diameter. Length gage: .726. Production: 100 per 2 machines per hour.

OPERATION 32.—*Filing butt tenon.*

Wood Light & Co. speed lathe is used, one machine per operator, work being driven with dog on centers. Cutting tool: 12-inch mill bastard file. Speed: 1800 r. p. m. Run dry. Gages: Ring 1.038-1.040. Production: 75 per hour.

OPERATION 32K.—*Inspection.*

This inspection covers operations 11, 11A, 12A, 24, 12B, 12W, 12, 24C and 32. Nine gages are required. Points gaged are length over all, length from butt to front end of fixed stud seat, size of barrel both front and rear of fixed stud seat and at three other points on body of barrel, size and length of tenon. Note that stock mark has been put on and observe condition of turning.

OPERATION 32½.—*Straightening bore, line system.*

Same as Operation 13.

OPERATION 32½K.—*Inspection.*

A visual examination of the bore for straightness is made in the manner described in Operation 13.

OPERATION 33.—*Hollow milling and shouldering butt tenon.*

Machine used: Pratt & Whitney horizontal 8-spindle. Number of machines per operator: One. Work is held in chuck to fit spotting on muzzle. Tool holders fit turret spindle. Cutting tools: 1 box tool; 1 face mill; 3 hollow mills. Cuts: 5. Speed: 200 r. p. m. Hand feed. Cutting oil: Lard. Average life of tools: About 150 barrels. Production: 63 per hour. Gages: 2 height; 2 diameter.

OPERATION 33K.—*Inspection.*

Four gages are required: 1 ring for 1.04-inch tenon; 1 ring 1 inch and 1 ring .997 inch for small tenon; and 1 shell gage .736 inch for length of tenon.

OPERATION 34.—*Thread milling for receiver and establishing draw line.*

Machine used: Pratt & Whitney thread miller, 4½ inches. Number of machines per operator: Two. Work is held by regular draw chuck in connection with special sleeve which fits over barrel near muzzle. Tool is held by thread milling arbor. Cutting tool: Milling cutter. Number of cuts: 1 milling thread and 1 burring top of thread. Speed: Barrel turns 30 r. p. m. Milling cutter, 240 r. p. m. Cutting oil: Lard. Gages: 1 threading; 1 size; 1 width .071-.053 inch. Production: 22 per hour per machine. A sub-operation marks the "draw" line by use of a small fixture.

OPERATION 34K.—*Inspection.*

Inspection of Operation 34 requires three gages—1 thread gage for size; 1 thread gage for draw of thread, and a maximum and minimum gage for width of thread. Inspector also observes depth and smoothness of thread and distance of end of thread from "draw line."

OPERATION 23.—*Milling front sight spline.*

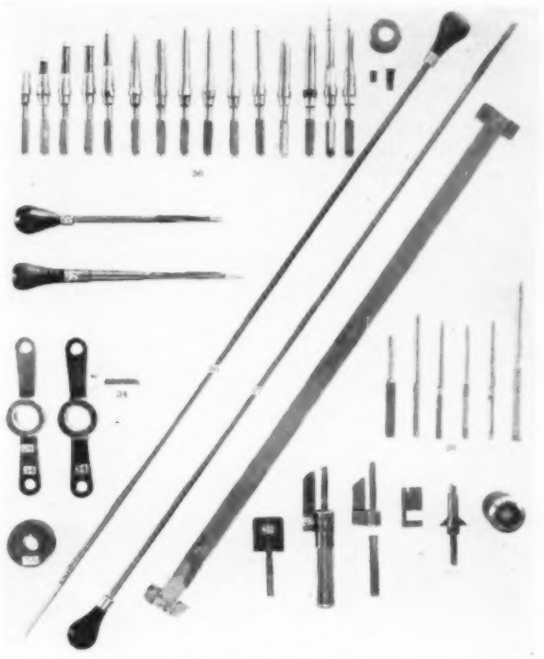
Machine used: Pratt & Whitney automatic miller, 5 inches. Number of machines per operator: Two groups, two machines per group. Work is held in special fixture; tool in 1¼-inch arbor. Cutting tool: Gang four mills. Number of cuts: Four per barrel. Speed: Arbor, 100 r. p. m. Cutting oil: Compound. Average life of tools: About 1,200 barrels. Gages: 1 height; 1 width. Production: 80 per hour per two groups. Location is taken from draw line.

OPERATION 39½.—*Stamping shell and flame, month, SA and year.*

A special stamping machine operated by one man is used. Barrel is rotated by hand with lever in special fixture. Tool holding device: Special arbor with steel stamps attached. Cutting tool: Special stamp roll. Number of cuts: One. No oil is used. Life of stamp: 3,000 barrels. Gages: None. Production: 140 per hour.

OPERATION 39½WK.—*Inspection.*

This inspection covers Operations 23, 39½ and 39½W. Operation 23, milling spline on muzzle of barrel 90 degrees from draw line must be accurate and is so determined by use of a bench block on which every barrel is placed with a center for muzzle and V block for butt. A straddle slide must go onto the spline at same time a V plunger enters the draw line. There is a snap gage for width of spline, a finger gage for height of spline and a finger gage, swing, for size of stud seat. Inspection of Operation 39½ is visual for location and distinctness.



Barrel, Caliber .30

Gages for checking operations, as numbered, on the barrel of the Springfield Rifle.

OPERATION 17.—*Reaming bore, .298-inch.*

Same as Operation 7, except as to size of reamer.

Inspection requires use of .298-inch plug gage and examination of bore for roughness and for rings.

OPERATION 26.—*Finish reaming bore, .300-inch diameter.*

Machine used: Pratt & Whitney horizontal barrel reamer, 2 spindle. Number of machines per operator: Five. Cutting tool is a seven-tooth scrape reamer. Number of cuts: Two. Speed: 110 r. p. m. Feed: 4½ inches. Cutting oil: Lard. Average life of tool between grindings: About 30 barrels. Gages: Two plugs. Production: 35 per hour. Reamer is pulled through bore with hollow reamer rod.

OPERATION 26BK.—*Inspection.*

A min. plug is passed entirely through bore. A max. plug must not enter. A visual inspection is made of inside of barrel for rings and rough reaming.

OPERATION 25.—*Straightening bore, ring system.*

This is a bench job. Barrel is placed in special fixture of Springfield Armory manufacture having butt and muzzle centers. Operator sighting through the bore notes the eccentricity of the rings formed by a strong light. By placing the barrel on babbitt block stand and striking it at the proper place with copper hammer, a skilled workman is able to cause all rings formed by reflected light to become concentric. The barrel is then straight. An average man will straighten 160 barrels per 8-hour day. One expert now on this work handles 225 per day.

OPERATION 27.—*Rifling.*

Machine used: Pratt & Whitney, No. 3, rifling machine. Number of machines per operator: Seven. Barrel is held by collet which clamps butt; muzzle is supported by bushing fitted to steadyrest on the machine. Cutting tool is a scrape cutter held in rifling head on rifling rod. Speed is about 7½ strokes per minute. Twist, uniform, one turn in 10 inches. Number of grooves: Four; width .1767-inch. Cutting oil: Lard. Gages: 1 taper; 1 straight. Production: 80 per day.

Operation 27K.—*Inspection.*

The operation of rifling is inspected by the use of three gages and by a careful visual inspection. A stabbing gage .3079 inch must pass entirely through every barrel. A taper plug (tapering from .3079 inch to .3090 inch is used. If any doubt exists about maximum size, a .3090-inch straight plug is used which must not enter barrel. After gaging, the barrel is given a close examination for width of land, shape of groove, torn land or groove, rough rifling, pitting and seams.

Operation 28.—*Burring thread shoulder.*

Barrel is held in the hand. Burrs are removed by use of hollow mill. Cuts: One. Average life of tool: 2,000 barrels. Gage: Threading gage with draw line. Production: 1,100 per 8-hour day.

Operation 35.—*Milling chamber ramp, rough.*

Machine used: Pratt & Whitney centering machine, No. 2. One machine per operator. Work is held in screw vise, tool with special arbor with pilot. Cutting tool: Mill. Cuts: One. Speed: 700 r. p. m. Hand feed. Cutting oil used. Average life of tool: 1,000 barrels. Production: 1,200 per day.

Operation 35½.—*Milling chamber ramp, finish.*

Machine used: J. G. Blount Co. speed lathe. One machine per operator. Work is held by threaded dog; tool by special arbor with pilot. Cutting tool: Mill. Cuts: One. Cutting oil used. Average life of tool: 400 barrels. Gage: Plunger. Production: 600 per day.

Operation 35½WK.—*Inspection.*

Operation 36.—*Chambering to finish.*

Machine used: Pratt & Whitney horizontal turret machine, 8-spindle. One machine per operator. Barrel is held in chuck made to fit Operation 23. Tool holders are specially made to fit turret spindles. Cutting tools: 1 combination cutting reamer 4-tooth; 1 body cutting reamer 5-tooth; 2 body scrape reamers 7-tooth; 1 neck cutting reamer 5-tooth; 1 neck scrape reamer 7-tooth; 1 bullet seat cutting reamer 5 tooth. Speed: Barrel turns at 150 r. p. m. Feed: Hand. Cutting oil: Lard. Average life of tools: 150 barrels. Gages: 14. Production: 30 per hour.

Operation 36A.—*Burring chamber.*

Barrel is held in hand of operator and the cut is made with spur tool held by two special made handles with attachment. Cuts: Two. Hand feed. Average life of tool: 2,000 barrels. Production: 1,400 per 8-hour day.

Operation 36AK.—*Inspection. Group* 36, *36A and 36B.*

Operation 36 entails the use of 14 gages, diameter, depth and taper, besides the collar, or cap; 5 of which are for size and depth of body; 6 for size and depth of neck; 1 for bullet seat; 1 called "overall," a perfect fit for the whole chamber; and 1 gage that contacts with only part of first shoulder. Inspector uses two reflectors to observe walls of chamber for rings and gouges. One reflector seats on first shoulder, the other seats on second shoulder. One gage is used for Operation 36A which is breaking corner where ramp cut and chamber meet.

Operation 37.—*Hand milling extractor cut.*

Machine used: Garvin Machine Co. hand miller, No. 3. One machine per operator. Work is held in fixture; tool is held by arbor and taper collet. Cutting tool: Milling cutter. Cuts: One. Speed: 200 r. p. m. Hand feed. Cutting oil: Machine. Average life of tool: 700. Gages: 1 bench gage for location and depth; 1 width gage. Production: 850 per day.

Operation 37A.—*Burring extractor cut.*

Barrel is held in hand of operator who makes one cut with Pillar File No. 0, size 6 inches by ½ inch wide. Life of tool: 3,600 per file. Production: 1,800 per day.

Operation 38.—*Milling muzzle to finish length and shape.*

Machine used: J. G. Blount speed lathe. One machine per operator. Barrel is held on center at butt and by an attachment at center to fit extractor cut. Cutting tool is a special mill—a facing mill with pilot held in arbor. Number of cuts: One. Average life of tool: 800. Cutting oil is used. Gages: 1 length gage and 1 for shape. Production: 800 per day of 8 hours.

Operation 38½.—*Hand milling seat for front sight fixed stud.*

Machine used: Brainard Milling Machine Co. hand miller. One machine per operator. Barrel is held in special fixture; tool held by collet to fit spindle. Cutting tool is a special milling cutter. Number of cuts: One. Speed: 320 r. p. m. Hand feed. Average life of tool: 400 barrels. Ring gage used. Production: 700 per day of 8 hours.

Operation 39.—*Filing barrel back of spline.*

Machine used: J. G. Blount Co. speed lathe. One machine per operator. Barrel is held by butt and muzzle centers. Cutting tools: 10-inch smooth file and No. 80 emery cloth. Cuts: One. Coolant: None. Gages: Snap. Production: 800 per day.

Operation 39K.—*Inspection of the following operations done as a group:* 37, 37W, 37A, 38, 38W, 38½ *and* 39.

Operation 40.—*Assembling rear sight fixed base and front sight fixed stud to barrel.*

Barrel is held in bench assembling fixture and work is done by hand by one man at rate of 800 per day.

Operation 40K.—*Inspection.*

Operation 41.—*Drilling and reaming front sight fixed stud and barrel for securing pin.*

Machine used: C. G. Allen 2-spindle drill press. Work is held in a special fixture; tool held in drill chuck. Cutting tool: No. 44 carbon drill; and 1 lip reamer. Cuts: Two. Speed: 1480 r. p. m. Hand feed. Coolant: Compound. Average life of tool: 400 barrels. Gage: Plug. Production: 125 per hour.

Operation 42.—*Drilling and reaming rear sight fixed base and barrel for securing pin.*

Machine used: Allen 2-spindle drill press. Number of machines per operator: One. Work is held in special fixture; tool held in drill chuck. Cutting tool: No. 44 carbon drill and 1 lip reamer .09 inch. Number of cuts: Two. Speed 1480 r. p. m. Hand feed. Coolant: Compound. Average life of tool: 300 pieces. Gage: Plug. Production: 65 per hour.

Operation 43.—*Pinning front sight fixed stud and rear sight fixed base to barrel.*

This is a bench job. Work is held in special bench block. Operation consists in driving two pins—one to secure fixed base and one to secure fixed stud to barrel. Production: 150 per hour.

Operation 44.—*Drilling spline pin hole in rear sight fixed base and barrel.*

Machine used: Pratt & Whitney 1-spindle drill press. One machine per operator. Work is held in special fixture and tool held in drill chuck. Cutting tool: No. 44 carbon drill; and 1 lip reamer. Number of cuts: Two. Speed: 1480 r. p. m. Hand feed. Cutting oil: Lard. Gages: Plug. Production: 125 per hour.

Operation 45.—*Assembling and driving securing pin in spline hole rear sight fixed base.*

A bench job. A wooden tray holds 10 barrels. Pins are driven in spline pin hole rear sight fixed base at the rate of 250 per hour per man. Gage: Straight edge.

Operation 46.—*Grinding and polishing ends of securing pins.*

Machine used: Bench grinder equipped with special arbor to hold alundum wheel 4 by ¼ inches with ½-inch hole, and a polishing wheel. Work is held in hand of operator and four cuts are taken, one on each end of the two pins. Speed of wheels: 3800 r. p. m. Coolant: None. Production: 60 per hour.

Operation 46K.—*Inspection. Covers Operations* 41, 42, 43, 44, 44W, 45, 45B *and* 46.

Operation 51.—*Straightening, ring system.*

Repetition of Operation 25.

Operation 51K.—*Inspection. Barrel is revolved on centers as before.*

Barrel is now finished and ready to be corked and packed for transfer to Hill Shops to be Parkerized.

Experimental Work At Springfield Armory

By Maj. Herbert O'Leary,* Ord. Dept., U. S. A.

SPRINGFIELD Armory is well known as the Government establishment at which fine military rifles have been manufactured for over a century. It is not so well known as a past or present manufacturer of many other familiar implements of defense, such as machine rifles, pistols, revolvers, bayonets, sabers, etc., and it is still less known as the establishment at which the activities of the Ordnance Department of the Army relating to the development and improvement of military small arms of all types are centered. Nevertheless, it is perhaps not too much to say that the most important function of the Armory, particularly during times of peace, is development and experimental work in connection with small arms and it is the purpose of this article to describe some of this work which is of current interest.

The field covered by the term "small arms" is a large and highly developed one and includes machine guns, machine rifles, automatic rifles, semiautomatic rifles, rifles, pistols, revolvers and all of the numerous accessories and appendages pertaining to this group of weapons. The calibers involved are almost as numerous as the weapons themselves and at the present time include 0.22-, 0.276-, 0.30-,

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Fig. 1. Types of Semiautomatic Rifles Considered by the Ordnance Department, U. S. A., Before the World War.
1. Murphy-Manning Rifle. 2. White-Greenman Rifle. 3. Farquhar-Hill Rifle. 4. Semiautomatic Rifle designed by Springfield Armory. 5. Semiautomatic Rifle—Rock Island type.

0.45- and 0.50-inch. All questions relating to the improvement of any of these weapons or to the design of new weapons to replace older ones are always referred to Springfield Armory for action of some sort prior to final consideration by the War Department. The action required may vary all the way from the mere expression of an opinion to the design of a new weapon or device including the construction and test of one or more models. In addition to this, Springfield Armory must always be prepared to conduct special tests and to furnish expert advice and opinions concerning the maintenance, care, functioning and use of the matériel in which it is so vitally interested.

Naturally, in order that the responsibilities just outlined may be met, adequate facilities are required and must be maintained continuously. An excellent description of the facilities available at Springfield Armory for development and experimental work, written by Maj. J. S. Hatcher, Ord. Dept., U. S. A., was published in the November-December, 1921, issue of Army Ordnance and this description is so complete that it is not believed that anything further need be added here.

Of even greater importance than material facilities is a force of highly trained and experienced personnel. A small force of this character in which each individual is an expert in his line has been built up and is maintained and if the efforts of the Armory to meet its obligations with respect to development and experimental work have met with any success in the past or are to meet with success in the future credit therefor must in a large measure be given to these employees. Their expertness and familiarity with questions affecting the design and functioning of small arms is the result of years of experience and study, supplemented by knowledge and traditions which have been passed on from generation to generation. In view of this it is seldom that any question relating to small arms ever arises which is not more or less intimately connected with some question or incident which has previously engaged their attention in one way or another and it is demonstrated almost daily that "there is nothing new under the sun."

THE following list of projects will furnish a fair idea of the scope and diversity of the work of an experimental nature at present receiving attention at Springfield Armory. In addition to those listed there are a number of projects of minor importance which it is not considered necessary to mention in this paper. A brief description of a few of the more interesting projects follows the enumeration.

Development of a suitable military semiautomatic rifle.

Improvement of the U. S. Rifle, caliber .22, M 1922, M1.

Investigation of the serviceability of noncorrosive caliber .22 long rifle ammunition and development of specifications for the procurement thereof.

Experimental work for the purpose of determining upon a means for gaging the serviceability of rifle barrels in the field which will be more satisfactory than the method at present specified by regulations.

Development of rear sights for rifles and machine guns which will be more suitable for service use than the present standard sights.

Investigation of the suitability of stainless steel for parts for small arms.

Tests of caliber .22 long rifle ammunition for the purpose of determining the relative erosive action of various types.

Determination of the accuracy life of barrels for caliber .45 service automatic pistol.

Investigation of the accuracy life of barrels for the caliber .50 machine gun.

Experimental work for the purpose of improving the functioning of the caliber .50 machine gun when it is used as an antiaircraft weapon.

Development of flash hiders for machine guns.

Test of recoil reducers, compensators, etc., for rifles and machine guns.

Development of the armorer's tool chest for use by the air corps.

Determination of the relative strength of receivers for the U. S. Rifle, caliber .30, M 1903, manufactured of various steels and at various times.

THE development of a semiautomatic shoulder rifle suitable for military use is one of the oldest and at the present time one of the most important problems of an experimental nature before the Ordnance Department. The development of a weapon of this type is based upon the age-old and ever-present demand for an increase in the fire power of the individual soldier, and its desirability is logical because it has been demonstrated that such a weapon will increase both the intensity of fire and its accuracy.

The last important step in connection with increasing the fire power of the individual was the introduction of the bolt-action magazine rifle. This occurred in our service shortly after 1890 when the caliber .30 Krag-Jörgensen rifle was adopted. The Krag-Jörgensen was replaced by the U. S. Rifle, caliber .30, M 1903, in 1903, and this rifle has since remained the standard weapon of the individual soldier.

In the case of both of these weapons a number of cartridges are loaded into a magazine which is an integral part of the weapon itself, and are fired one after another by manually opening and closing the bolt and pulling the trigger for each shot. Opening the bolt results in clearing the chamber of the barrel by extracting and ejecting the fired case from the round just fired and closing it loads the next round into the chamber in readiness for the next shot. These operations are at times somewhat difficult to perform and always consume considerable time besides disturbing the aim of the firer.

A semiautomatic rifle is operated in a manner similar to that just described except that the opening and closing of the bolt is performed automatically by suitably using a small portion of the power developed when each cartridge is fired. Therefore more aimed shots can be fired in the same length of time from such a rifle than can be fired from the magazine rifle. Further, the firer can devote more of his time to maintaining the alignment of his sights on the target and prolonged firing is less fatiguing, both of which factors will tend to increase the number of hits per round fired.

The advantages of a semiautomatic rifle were recognized at an early date and the M 1903 rifle had hardly been adopted before the Ordnance Department in general, and

Fig. 2. Types of Semiautomatic Rifles Considered by Ordnance Department, U. S. A., During the World War.

1. Mondragon Rifle. 2. Stergian Rifle. 3. Rychiger Rifle. 4. Elder Rifle, Rychiger type. 5. Bommarito Rifle. 6. Liu Rifle. 7. Liu Rifle. 8. St. Etienne Rifle.

Springfield Armory in particular, began to give the matter serious consideration. The problem is a most difficult one and has received constant consideration for over 25 years. Everything possible has been done to interest inventors and to encourage them to design and submit models for test and the Ordnance Department itself has devoted a great deal of effort in an attempt to develop a suitable design. Up to the present, models of many different designs have been tested and much valuable information has been gathered but the Ordnance Department has not yet obtained or produced a type of semiautomatic rifle which it is willing to recommend to the War Department for adoption. However, it should be noted that recent developments are promising and it is confidently expected that a type will be recommended during the next two or three years.

THE following statements quoted from some of the annual reports of the Chief of Ordnance and the weapons shown in Fig. 1 indicate the amount of work which had been done on this project up to the beginning of the World War:

Report for the year 1902.

"The only radical improvement in muskets which is now known to be under study is the application to these arms of the automatic principle, to the extent of causing the musket itself to effect its own reloading upon discharge. The principle has been already applied with some extent to pistols, and its advocates claim that it is logically in the line of development of the magazine rifle, in reducing to a minimum the interval between aimed shots. Both tactical and mechanical questions are involved in the consideration of the possible desirability of the substitution of a semiautomatic musket for the hand-operated magazine rifle. Up to the present time mechanical invention has not solved its part of the problem, and no rifle of the class has been presented to this Department for examination and test, although its willingness to take the subject up has been signified whenever occasion has offered."

Report for the year 1903.

"The subject of an automatic musket is in about the same state as described in my last annual report—that is, no musket of satisfactory mechanical action has been presented to the Department, and therefore the tactical question of the desirability of the adoption of such an arm does not come up for consideration. The Department is encouraging inventors who approach it upon the subject of the production of an automatic musket, as it seems that the principle—being in line of the reduction of the interval between aimed shots—follows the course which led to the introduction of the magazine rifle, and has therefore at least sufficient promise of value to be worthy of attention to the degree necessary to advance the question from a mechanical to a military one."

Report for the year 1904.

"The subject of the automatic musket is in about the same state as described in my last annual report, although it is anticipated that more than one design will be ready for test during the coming year."

Report for the year 1905.

"Different designs of self-loading muskets have been subjected to preliminary tests during the year, and the results indicate that material progress is being made in their development."

Report for the year 1906.

"The test of the Schuboe auto-loading magazine rifle has been continued during the year. As the result of these tests, changes are being made in the rifle which may eventually render it satisfactory for service use. An auto-loading magazine rifle is also being developed at the Springfield Armory, and should be completed and subjected to test during the coming year."

Report for the year 1907.

"The test of the Schuboe automatic magazine rifle has been continued during the year. Experiments are continuing with this class of gun at Springfield Armory."

Report for the year 1910.

"The department is endeavoring to develop or procure a semiautomatic shoulder rifle which will prove satisfactory as a military weapon. Three designs developed in the department are being given preliminary and shop tests. Two designs of rifles submitted by private individuals have been tested to some extent. This subject is still considered to be in an experimental stage, but there is some promise of ultimate success."

Report for the year 1911.

"Several preliminary tests of semi-automatic shoulder rifles, designed by this department and submitted by private individuals, have been conducted during the past year. The results of the tests show that a satisfactory design of semiautomatic shoulder rifle for military use has not yet been developed, and that the subject is still in an experimental stage. However, some progress has been made since my last report."

Report for the year 1912.

"Tests of semiautomatic shoulder rifles, designed by this department and submitted by private individuals, have continued during the past year. The rifles tested, while not developed sufficiently to warrant adoption for use in the military service, have nevertheless shown results which have been encouraging."

Report for the year 1913.

"Tests of semiautomatic shoulder rifles, designed by this department and submitted by private individuals, have been continued during the past year. The department's endeavors to encourage private individuals in their work of designing such a rifle have met with some success. Several requests for tests of rifles along the type desired have been received, showing that an interest is being taken in the matter by inventors. One of the rifles tested, while not developed sufficiently to warrant adoption for use in the military service, has shown promising results."

Report for the year 1914.

"Tests of semiautomatic shoulder rifles, both designed by this department and submitted by inventors, have been continued throughout the year. During the year there has been designed at the Springfield Armory one of these rifles which has given good promise. Action has been taken by this department to obtain a price at which there could be procured a limited number of semiautomatic shoulder rifles similar to the one which has previously been tested at the

Fig. 3. Caliber .30 Semiautomatic Rifles Tested at Springfield Armory in 1920 by a War Department Board.
1. Garand Rifle. 2. Thompson Rifle. 3. Berthier Rifle. 4. U. S. Semiautomatic Rifle, Model 1920, Experimental (Bang type).

Springfield Armory with very promising results. If this price is satisfactory it is contemplated that purchase of some of these rifles, for test, will be made."

Report for the year 1915.

"After making certain minor changes in the firing mechanism to overcome defects developed in preliminary trials, test of the Bang rifle has been completed. The result of the test indicates that, while promising, this arm in its present stage of development does not fulfill the requirements for a military arm of this type.

"A preliminary test of the Rychiger semiautomatic shoulder rifle also gave promising results; but, due to lack of ammunition, the test to which all such rifles must be subjected was not carried to completion. The rifle, and the ammunition therefor, are made abroad, and owing to the European war some trouble has been experienced in securing the necessary quantity of ammunition to complete the test.

"Considerable work has been done on the semiautomatic shoulder rifle designed at the Springfield Armory. So far, however, it has been impossible to obtain sufficient certainty or reliability of action. A modified design of this rifle has been completed and is now being tested."

THROUGHOUT the period of the World War consideration was given to the development of a satisfactory weapon. Several individual designs were tested but none was found to be entirely satisfactory. Figure 2 shows a few of the types which were given consideration during this period.

After the World War it was thought that competitive tests might stimulate interest in the subject and thus be productive of good results. Two such tests were held by Boards convened by the War Department for the purpose, one in 1920 and the other in 1921. In the first test, models of four designs were considered. Models of two of the designs were prepared at Springfield Armory and the models of the other two designs were submitted by civilian inventors. Of the two designs prepared at Springfield Armory one was the invention of a civilian employee of the Armory, Mr. J. C. Garand, and the other was a modification of the Bang semiautomatic rifle constructed under the personal direction of an officer of the Ordnance Department. The Bang rifle was submitted by a foreign inventor and tested with promising results several years before the beginning of the World War and appeared to have features worthy of further development. Of the two submitted by private inventors, one was the invention of

Brig. Gen. J. T. Thompson, U. S. Army, Rtd., a former officer of the Ordnance Department, and the other was essentially the same as the caliber .30 Berthier machine rifle which had been tested with excellent results during the World War. These four rifles are shown in Fig. 3.

None of these rifles was considered to have sufficient merit to justify a recommendation for adoption but the Board which conducted the tests concluded that a rifle either of the Bang type or the Garand type would be most likely to meet the requirements of the using services. For various reasons the Board did not consider that the other two types of rifle could be made acceptable for service use.

For the 1921 competitive test only three semiautomatic rifles were submitted, two of which were of the Thompson type and one of the Berthier type. The Ordnance Department did not submit any weapons for this test because the further development of the Garand and Bang types, which was continued after the 1920 tests, had not progressed sufficiently to justify test at that time. The two types which were submitted were essentially the same as similar types submitted in 1920 and the Board which conducted the tests did not find that either was suitable for service use.

After the 1920 test Springfield Armory continued the development of the Garand and Bang type rifles but, as noted, improved models were not ready in time for submission to the 1921 War Department Board. Models, however, were ready early in 1922 and they were subjected to test by a Board convened for the purpose by the Commanding Officer, Springfield Armory. The Bang type of rifle failed structurally and, although it was still thought that many features of the design were excellent, further work was held in abeyance due to the non-availability of funds and competent personnel with which to carry it on. The Garand type of rifle also failed structurally during the test but it did much better than the Bang and, upon recommendation of the Board, it was repaired after which it passed the usual tests in a credible manner.

Early in 1922 it appeared advisable to supply the using services with a limited number of semiautomatic rifles in order that the tactical usefulness of such a weapon might be determined. To appraise the using services of the latest developments in the field of semiautomatic rifles it was felt that two types should be supplied, one type to be representative of the most promising weapon developed by private enterprise which could be procured readily and the other type to be the most promising type thus far developed by the Ordnance Department itself. Accordingly 20 weapons of the Thompson type were procured from the inventor and 24 of the Garand type were manufactured at Springfield Armory. These were issued early in 1925 to the Infantry Board at Fort Benning, Georgia, and the Cavalry Board at Fort Riley, Kansas. Preliminary consideration by the two Boards resulted in recommendations that the stocking and sighting of both types be improved. These recommendations were complied with and the rifles were again submitted to the two Boards.

UP TO 1923 the endeavor of the Ordnance Department and of civilian inventors had been to produce a semiautomatic rifle which would fire the standard caliber .30 service cartridge. Twenty years of effort, however, had failed to produce a satisfactory design. This is not surprising in view of the great power developed by the cartridge and the necessity for keeping the weight of the weapon down to the minimum. The U. S. Rifle, caliber .30, M 1903, which weighs approximately eight and one-half pounds is as light as a weapon can be made which will successfully fire this cartridge and at the same time meet other military requirements. Further, it has been decided that a suitable shoulder weapon should not weigh appreciably more than this amount. As already noted, the M 1903 rifle is a manually operated weapon whereas a semiautomatic rifle is one in which some of the operations in connection with firing are performed automatically by power developed by the firing. It will be appreciated that to make provision for this automatic feature and yet not increase the weight materially above the eight and one-half pounds which is considered near the maximum permissible weight is a very difficult problem. It can also be appreciated that if the power of the cartridge were reduced by either reducing the muzzle velocity or decreasing the caliber, or by both, the problem would be greatly simplified.

Consideration of the matter convinced the Ordnance Department that if the caliber were reduced from 0.30-inch to 0.276-inch (7-mm.) and the weight of the bullet from 150 grains to approximately 125 grains, it would be a comparatively simple matter to design a semiautomatic rifle within the specified weight limit. Having arrived at this conclusion it then became necessary to determine whether any reduction in caliber and bullet weight would be justified for experimental purposes. The experiences of the World War had pretty clearly demonstrated that the maximum effective range of rifle fire is never greater than 1,000 yards and is almost always less than this distance. It appeared, therefore, that a weapon which would be effective at all ranges up to a thousand yards would meet every essential requirement.

So far as accuracy and ranging are concerned it was known that a 0.276-inch cartridge could be made which would cover these ranges effectively but little or nothing was or is known concerning the relative stopping power or shock effect of the caliber .30 service bullet weighing 150 grains and the proposed caliber .276 bullet weighing only 125 grains. It is certain, however, that the latter is less effective in this respect than the former but whether it still has sufficient stopping power to answer requirements is unknown. In any event, the smaller caliber seemed to have advantages not possessed by the larger caliber which would tend to offset to some extent its deficiency in stopping power. In this connection it is to be noted that the heat generated by the firing of the caliber .30 cartridge is much greater than in the case of a caliber .276 cartridge which would be considered satisfactory for military use with the possible exception of its lack of stopping power, and for this reason a semiautomatic rifle designed to fire the caliber .30 service cartridge would undoubtedly become unserviceable due to over-heating from continuous firing in a shorter length of time than would a semiautomatic rifle designed to fire the caliber .276 cartridge. Of the two cartridges the caliber .276 would weigh approximately 22½ per cent. less than the caliber .30 service cartridge* and if it is assumed that the two rifles weigh the same this would of course permit the individual to carry a correspondingly greater

*This comparison is based upon the caliber .30, M 1906, cartridge. If the comparison is based upon the caliber .30 M1 service cartridge which has been adopted to replace the M 1906 cartridge the percentage reduction in weight becomes 29 per cent.

amount of ammunition into combat. A further advantage of the smaller caliber over the larger caliber which is worthy of consideration is the reduction in recoil which would result in less fatigue to the firer with a possible corresponding increase in the length of time during which he would be able to shoot accurately.

Due consideration of the pros and cons of the matter led to the decision that a reduction in caliber and bullet weight to 0.276-inch and 125 grains respectively offered sufficient promise of a solution of the semiautomatic rifle problem to justify the design and construction of one or more models for test purposes. To obtain the engineering talent required in the design of a semiautomatic rifle which would fire a caliber .276 cartridge a contract was entered into with Mr. J. D. Pedersen, a civilian gun inventor. In accordance with the terms of the contract Mr. Pedersen was to design the weapon and perform the necessary engineering work in connection therewith and the Ordnance Department was to construct a model of the weapon at Springfield Armory. The contract was entered into in May, 1923, and the pilot model was demonstrated in Washington, D. C., in December, 1925. Later on the pilot model was demonstrated to the members of the Infantry and Cavalry Boards. Its mechanical functioning in all of the demonstrations, as well as in a test conducted at Springfield Armory under the supervision of the Commanding Officer of that establishment, was so promising that it was decided to manufacture 20 additional weapons so that 10 each could be supplied to the Infantry and Cavalry Boards for test purposes. These 20 rifles were manufactured at Springfield Armory and were supplied to the Infantry and Cavalry Boards in September, 1927.

It is thus seen that a limited number of each of three types of semiautomatic rifle have been supplied to both the Infantry Board and the Cavalry Board for test purposes. Two of the three types fire the caliber .30 service cartridge and the third type fires a cartridge with a bullet of .276 caliber and weighing 125 grains. These three types have been supplied for the purpose of informing the using services concerning the latest developments which have taken place in connection with the attempt to obtain a weapon which will be satisfactory for service use and so that the tactical usefulness of a semiautomatic rifle as a component part of the armament of our combat troops might be determined by practical field tests. In reference to the latter it is believed that the tests which have thus far been completed clearly indicate that a semiautomatic rifle has sufficient advantages to justify its adoption for service use.

Fig. 4. Three Types of Semiautomatic Rifle Recently Submitted to the Infantry and Cavalry Boards for Test Shown in Comparison with the Caliber .30 M1 1903 Service Rifle.

1. U. S. Rifle, Cal. .30 M 1903, 24-in. barrel. 2. Pedersen Semiautomatic Rifle, Cal. .276, 24-in. barrel, 10 round magazine. 3. Garand Semiautomatic Rifle, Cal. .30, 24½-in. barrel. 4. Thompson Semiautomatic Rifle, Cal. .30, 21½-in. barrel.

THE advantages which will result from arming our troops with a semiautomatic rifle having been clearly demonstrated, the next most important matter in connection with this project is the determination of the caliber. Design work heretofore done clearly indicates that a semiautomatic rifle which will operate successfully with the present service

cartridge can be made and this being so it naturally follows that one which will successfully fire a cartridge of smaller caliber can also be made. Therefore as soon as the caliber has been determined upon we should not have to wait long before a mechanically satisfactory weapon can be supplied for extended field tests. The determination of caliber is a War Department matter and can probably best be determined by a Board of Officers composed of representatives from all the using services and from the Medical and Ordnance Departments.

After the question of caliber has been settled the next step should be the selection of that type of mechanism most suited for military use, in other words, the most reliable mechanism from the point of view of mechanical operation which it is possible to obtain. Best results in this respect can probably be obtained by having a competitive test at a time sufficiently far in the future to permit all interested parties to prepare and submit models of the specified caliber for consideration and test. Such a test should be conducted by a Board appointed by the War Department and should be open to everyone interested in the matter.

Pending the determination of caliber Springfield Armory is working on three models in an endeavor to produce improved designs. Two of these models are being constructed under the supervision of Mr. Garand and are of the same design but one is for the caliber .30 service cartridge and the other for the caliber .276 cartridge. The fundamental design of these two models is somewhat different from the design previously worked upon by Mr. Garand and it is expected that it will embody a number of features which are superior to anything heretofore included in a semiautomatic rifle. The third model is being constructed under the supervision of Mr. Pedersen and, although fundamentally the same as the first design constructed under his supervision, it will be mechanically somewhat simpler than the first model. These three models should be completed within the next few months and will represent the last word in semiautomatic rifle design so far as the efforts of Springfield Armory along this line are concerned.

THE U. S. rifle, caliber .22, M 1922 M1, is a caliber .22 bolt-action rifle designed to fire the caliber .22 long rifle cartridge. The development of this weapon was started at Springfield Armory in 1915 but the World War interfered with its completion. Work, however, was resumed after the war and the weapon was completed and adopted for issue to the service in 1922. The weapon, designed primarily for target use, follows the caliber .30 service rifle very closely in weight, balance and method of operation and it has been adopted by the service to afford a convenient and economical means for supplementing training with the regular caliber .30 service rifle.

The fundamental design of the caliber .22, M 1922 M1 rifle is thought to be excellent and great care is exercised in its manufacture in order that the final product will measure up to the best standards of Springfield Armory and so that the requirements placed upon it by the service will be fulfilled in a satisfactory manner. However, no mechanism is so nearly perfect that it cannot be improved and this rifle is no exception to this general rule.

Some 15,000 have been manufactured most of which have been issued to the service or sold to those authorized to purchase Ordnance matériel. Extended use of the weapon since its manufacture started has brought to light many of its deficiencies and constant attention has been given to the development of ways and means for their elimination. In connection with this development, two experimental models have been constructed both of which include important improvements along lines indicated by reports of functioning which have been received from the service and from private purchasers. The first model, known as the U. S. Rifle, caliber .22, T1, was somewhat of a compromise and did not include all of the improvements which could be made but it went about as far in this respect as it was thought advisable to go at the time. This model was followed by a second model known as U. S. Rifle, caliber .22, T1 E1, in which, in the opinion of the Armory, all of the more important improvements considered of advantage have been incorporated.

The principal defects of the M 1922 M1 model which have been brought to light include breakages of the bolt head retaining lug on the bolt, failures of the cartridge to feed properly from the magazine into the chamber of the barrel, failures to extract and eject properly and poor positioning of the magazine. The T1 E1 model includes a complete new bolt which might be said to be fundamentally the same as the old bolt but in which the design of the components has been changed to overcome defects and improve functioning. The old bolt latch has been eliminated and a much stronger bolt head retaining lug has been made. The position of the extractor on the bolt has been changed to a more favorable one and its design has been improved, the combined result of which is to insure positive extraction under all conditions. The magazine clearance cut on the bolt has been made deeper so as to permit the top part of the magazine, and therefore the top cartridge in the magazine, to assume a position nearer the center of the bore to improve feeding. The face of the bolt head has been modified also to improve feeding. The design of the ejector has been modified to improve ejection and eliminate binding of firing pin thus insuring more uniform ignition. A new one-piece firing pin has been provided to give more positive ignition and greater speed and to get away from the cushioning effect which occurs with the two-piece striker of the M 1922 M1 model. The striker head and the cocking cams have been changed and the weight of the mainspring has been somewhat increased. The design of the guard has been changed throughout to eliminate the floor plate used in the M 1922 M1 model and to locate more positively the magazine and hold it under spring tension so that it will not be pushed out of location each time the bolt is operated. The new guard includes a more accessible magazine release and one which is more positive in its operation. The barrel has been moved back in the receiver a short distance to improve the ease of loading single shots by hand as is done in slow fire and to shorten the distance which the cartridge must travel from the magazine to the chamber when magazine loading is employed, thus to eliminate the jump of the cartridge which frequently causes malfunctions. The angle of the extractor cut in the rear end of the barrel has been changed slightly to improve the feeding of the cartridge into the chamber and to improve extraction. Figure 5 shows how the feeding of cartridges from the magazine into the chamber has been improved by these various changes.

The improvements noted above have been worked out experimentally and incorporated in one model only. Considerable expense would be involved in case manufacture

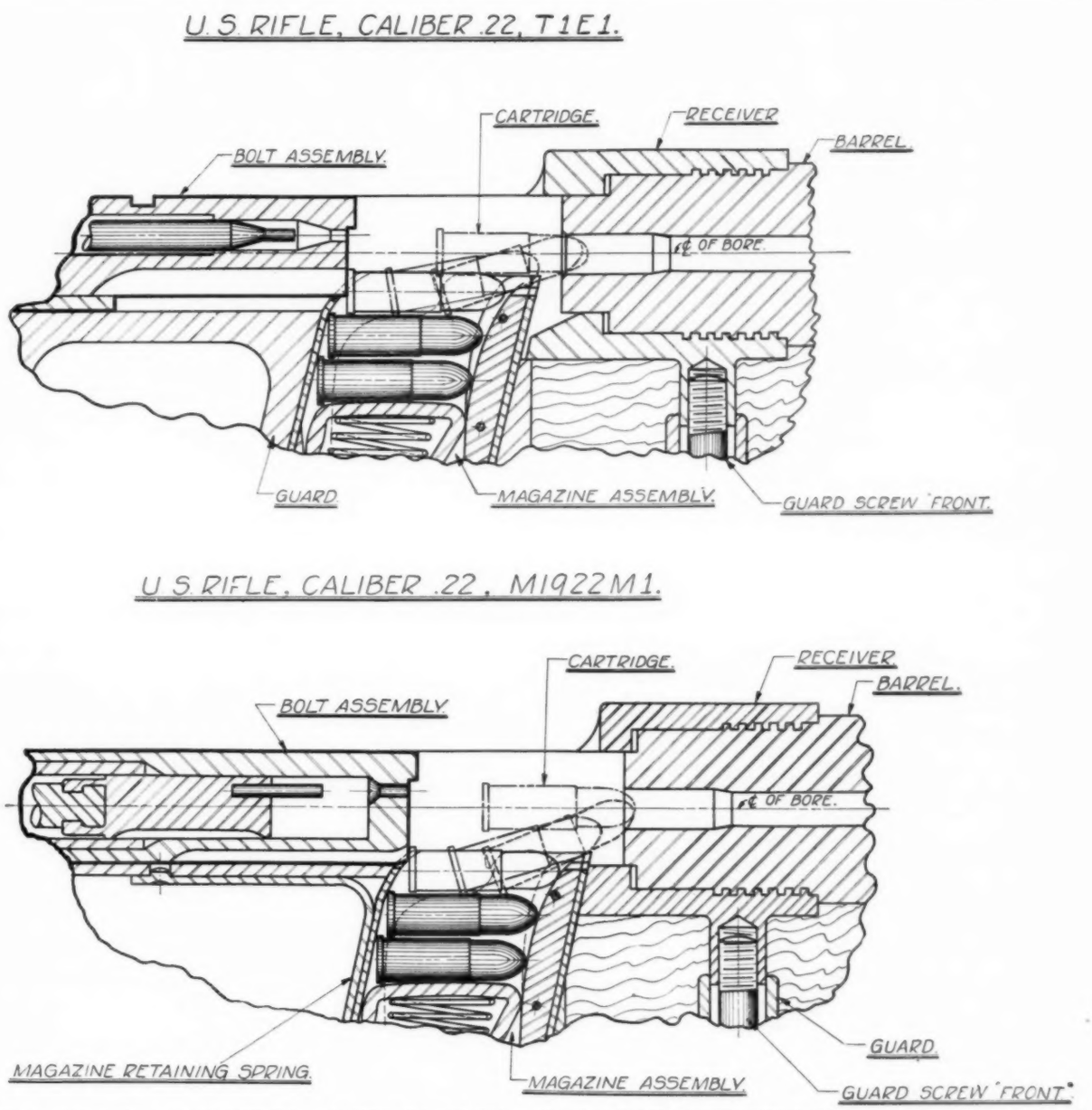

Fig. 5. Comparison of M. 1922 M1 and T1E1 Cal. .22 Rifles Showing the Manner by Which Feeding of Cartridges from the Magazine into the Chamber has been Improved in the Latter.

were changed from the present model to the improved model and for this reason it is not known when the improved model can be manufactured for issue or sale but probably not in the near future. This is to be regretted inasmuch as the T1 E1 rifle, equipped with the M1 sight, described below, would be greatly superior to any caliber .22 target rifle now on the market.

Another great improvement which has been developed for the caliber .22 rifle is the rear sight. All of these rifles which have been manufactured are equipped with the Lyman No. 48 receiver sight. This is an excellent sight and fulfills requirements in a fairly satisfactory manner. However, it has been possible to design a rear sight at Springfield Armory which it is believed is greatly superior to the Lyman sight. Apparently the using services concurred with the Ordnance Department in this thought because as a result of tests which were conducted some time ago it was recommended that the sight be adopted for future manufacture and this recommendation was approved by the War Department. The new sight is known as the caliber .22 rifle sight, M1. In connection with the adoption of this sight, however, it should be noted that none have yet been manufactured except for experimental purposes, and it is not known when manufacture in quantity can be undertaken due to lack of funds. Present indications are that this will not be in the immediate future.

AS pointed out in the first part of this paper, Springfield Armory is the center of the activities of the Ordnance Department relative to all matters pertaining to small arms and it is seldom that the establishment is required to devote more than casual attention to other types of ordnance. However, about two years ago one of the commercial ammunition manufacturers began to give great prominence in his advertising and otherwise to a new type of caliber .22 ammunition which he was proceeding to place

on the market. This ammunition was a so-called non-corrosive ammunition and it was claimed that after firing it in a rifle the rifle could be set aside without cleaning or other attention for an indefinite period and the bore would not rust or corrode. It was evident that an ammunition of this type would be particularly advantageous for service use in the M 1922 M1 rifle provided the claims made for it were true because in the past for every caliber .22 rifle barrel which was worn out by shooting at least ten became useless due to after-firing corrosion which resulted from improper cleaning or no cleaning at all. Springfield Armory was accordingly directed to determine its suitability for service use with the M 1922 M1 rifle and several interesting experimental tests have been conducted since. In addition to these tests the Armory has made all purchases of caliber .22 long rifle ammunition required by the Ordnance Department for issue and sales purposes.

To understand what is meant by non-corrosive ammunition it is to be noted that the residue left in the bore of a fire arm by the various types of primers used in this country up to two or three years ago, and which are still almost generally used in the case of center-fire cartridges, has a great affinity for moisture. Therefore, if this residue is left in the bore or is only partially removed, rusting and pitting, known as after-firing corrosion, is almost certain to take place. The residue left by black powder possesses the same characteristic but smokeless powder is not open to this objection. It will therefore be correctly deduced that a non-corrosive ammunition is one in which the residue left in the bore by the primer and powder are inert insofar as its tendency to induce after-firing corrosion is concerned.

Before the introduction of non-corrosive caliber .22 long rifle ammunition, such ammunition was loaded with the older type of primer composition and with lesmok or semi-smokeless powder, both of which powders are essentially mixtures of black powder and smokeless powder. Therefore, the fouling of a caliber .22 rifle caused by either the primer or powder was objectionable in that any trace of either left in the bore of the barrel after firing would be active in inducing after-firing corrosion. However, as between the two the primer fouling is much more active than the powder fouling and in view of the fact that at the time the development of non-corrosive ammunition was undertaken lesmok or semi-smokeless powder was the standard powder for the most accurate grades of caliber .22 ammunition, the primer only was at first replaced by one which was non-corrosive.

A small quantity of such ammunition, that is, ammunition loaded with non-corrosive priming and lesmok powder, was procured and subjected to test. As might have been expected, because of the presence of black powder in the powder charge, it was found that this ammunition was not entirely non-corrosive in that the rusting and pitting of the bore which took place after it was fired in a rifle and the rifle then set aside without cleaning in a humid atmosphere for a few days was greater than in the case of a rifle which was treated in a similar manner with the exception that it was not fired. From the results of this test it was concluded that to be truly non-corrosive, ammunition should be loaded not only with non-corrosive priming but also with smokeless powder which leaves a residue which is inert so far as inducing corrosion is concerned.

After the test just described it was considered advisable to procure approximately 1,000,000 rounds of non-corrosive ammunition to provide for a more extended investigation and to determine whether the development of this type of ammunition had proceeded to the point where its procurement in quantity seemed to be justified. Bids to supply this ammunition were requested in the usual manner and it was stipulated that any sample of ammunition to be satisfactory must meet a given standard when tested for accuracy. It was further stipulated that such of the samples as successfully met the accuracy requirement would be subjected to a comparative test for the purpose of determining the relative non-corrosiveness of such samples. It was provided that that type of ammunition which showed a satisfactory degree of accuracy and was the least corrosive would be procured and that if two or more samples which passed the accuracy test were equally satisfactory in respect to non-corrosiveness then the ammunition for which the lowest price was quoted would be procured. Four manufacturers each submitted two samples of ammunition in response to the invitation for bids. One sample submitted by each manufacturer was loaded with lesmok or similar powder and non-corrosive priming and the other sample with smokeless powder and non-corrosive priming. In the test for accuracy four samples failed and were eliminated. One sample which passed the accuracy test was eliminated because its mechanical functioning in the rifle was not satisfactory. Three samples were accepted insofar as accuracy and mechanical functioning were concerned and were subjected to appropriate tests to determine their relative corrosion-resisting qualities. Two of these three samples were loaded with smokeless powder and one with lesmok powder and as already noted all contained non-corrosive priming. In this test the samples loaded with smokeless powder clearly demonstrated their superiority over the sample loaded with lesmok powder with respect to resistance to after-firing corrosion.

The test just described created considerable interest and it is believed has had some effect in stimulating the development of non-corrosive caliber .22 ammunition which is truly non-corrosive and which is reasonably accurate. After the completion of this test specifications for caliber .22 long rifle ammunition especially adapted for use in the caliber .22 rifle, M 1922 M1, were prepared and these specifications require that all such ammunition shall be loaded with non-corrosive priming and smokeless powder. Since the preparation of the specifications some seventy million (70,000,000) rounds of this type of ammunition have been procured and it is probable that the Ordnance Department will be in the market for an additional supply within a reasonable time.

The test to determine the corrosion-resisting qualities of an ammunition which was developed in connection with the investigation of non-corrosive caliber .22 ammunition at Springfield Armory is a rigid one and has been found to be very effective in determining whether a so-called non-corrosive cartridge is in reality non-corrosive. In this test fifty rounds of the ammunition to be tested are fired through a rifle and then without cleaning of any sort the rifle is subjected to the action of live steam. It is placed in a suitable compartment and the steam is turned on for a sufficient length of time to permit of the formation of moisture on the exterior of the weapon. This treatment is repeated six times with intervals of several hours between each treatment during which the rifle is set aside in a room

at ordinary temperature. During the continuance of the test the bore of the barrel is examined from time to time for evidences of corrosion and at the conclusion of the test the bore is carefully cleaned and examined for pitting. If the ammunition is satisfactory no indications whatever of rusting or pitting will be discernible.

The erosion caused by non-corrosive caliber .22 long rifle ammunition is a matter of considerable importance and has not yet been thoroughly investigated by the Ordnance Department. Such an investigation, however, is under way and preliminary results seem to indicate that it is more erosive than the older type of ammunition loaded with the older type of priming and lesmok or similar powder, but it is yet too early to say whether it is objectionable in this respect. There has always been on the market a type of caliber .22 ammunition loaded with smokeless powder and it is known that this ammunition is particularly objectionable because of its great erosive action. This ammunition is not to be confused, however, with non-corrosive ammunition loaded with smokeless powder because it is not thought that the erosive action of the latter is anywhere near as great as that of the former.

In addition to obtaining ammunition which is non-corrosive it is extremely desirable to obtain the most accurate and uniform ammunition practicable to obtain and since the Ordnance Department started to demand great accuracy in the ammunition procured by it there has been a very marked improvement in this respect. Approximately twenty months ago when the characteristics of non-corrosive caliber .22 ammunition were first investigated six rifles were used and the means of the mean radii of a number of targets fired from each rifle at a range of 100 yards were as follows:

	1st Make of Ammunition	2nd Make of Ammunition	3rd Make of Ammunition
1st Rifle	0.99-inch	0.90-inch	1.01-inch
2nd Rifle	0.89-inch	0.89-inch	0.84-inch
3rd Rifle	0.84-inch	1.08-inch	0.91-inch
4th Rifle	0.75-inch	0.88-inch	0.91-inch
5th Rifle	0.76-inch	0.87-inch	0.80-inch
6th Rifle	0.86-inch	1.11-inch	0.86-inch
	5.09-inch	5.75-inch	5.33-inch
Average	0.848-inch	0.955-inch	0.888-inch

One of the three types of ammunition used was non-corrosive and the other two types ordinary ammunition as manufactured by all companies at that time and the results noted above were on the average as good as could be expected. In the next test, which was conducted some months later, eight rifles were used and three makes of ammunition each loaded with non-corrosive priming and lesmok powder were fired in four of the rifles and four other makes each loaded with non-corrosive priming and smokeless powder were fired in the other four rifles. The means of the mean radii in this test were as follows:

	1st Make of Ammunition	2nd Make of Ammunition	3rd Make of Ammunition
1st Rifle	0.887-inch	0.808-inch	0.986-inch
2nd Rifle	0.792-inch	0.635-inch	0.799-inch
3rd Rifle	0.782-inch	0.783-inch	1.041-inch
4th Rifle	0.809-inch	0.574-inch	0.899-inch
	3.270-inch	2.800-inch	3.725-inch
Average	0.817-inch	0.700-inch	0.931-inch

	4th Make of Ammunition	5th Make of Ammunition	6th Make of Ammunition	7th Make of Ammunition
5th Rifle	0.667-inch	0.967-inch	0.976-inch	0.788-inch
6th Rifle	0.690-inch	1.028-inch	0.862-inch	0.797-inch
7th Rifle	0.756-inch	0.840-inch	1.040-inch	0.647-inch
8th Rifle	0.605-inch	1.138-inch	0.808-inch	0.920-inch
	2.718-inch	3.973-inch	3.686-inch	3.152-inch
Average	0.679-inch	0.993-inch	0.921-inch	0.788-inch

More recently in the test of a number of makes of ammunition it has been demonstrated that it is possible to manufacture caliber .22 long rifle ammunition which will consistently make targets at 100 yards with mean radii between 0.60-inch and 0.75-inch. The present specification for accuracy used in the procurement of caliber .22 long rifle ammunition requires an average mean radius of 0.85-inch, but it is quite possible that this figure will be reduced materially within a short time.

IT has been long recognized that the amount of wear in the bore of a rifle barrel at the breech end at and immediately in front of the bullet seat is a controlling element in the accuracy of the barrel. A convenient method of determining the amount of this wear in the field has never been developed. However, some 15 years ago the question was thoroughly investigated and a method of determining whether a rifle barrel is sufficiently accurate for retention in the service was developed and adopted and this method is still in use.

In the investigation which preceded the adoption of this method it was established to the satisfaction of all concerned that the wear of the bore of a rifle barrel at the breech end is a function of the wear at the muzzle end. The wear at the muzzle end can be very conveniently and simply measured by means of plug gages and this at once suggested a convenient means for indirectly determining the wear at the breech end. Two plug gages are used for this purpose one somewhat larger than the other. If the larger gage enters the muzzle end of the bore it is assumed that the wear at the breech end is so great that the barrel will not shoot as accurately as required for service use and it is discarded forthwith. In case the smaller gage will not enter at all it is assumed that the barrel is sufficiently accurate for retention in the service. In case the smaller gage enters and the larger gage does not enter, the accuracy of the barrel is questionable and in order that its serviceability may be definitely determined it is actually fired at a known range and its serviceability determined by the result of this firing.

In an endeavor to evolve a more practicable method of inspection, an investigation was started at Springfield Armory about two years ago and thus far in this investigation some 18 new barrels have been used. Each barrel has been or is being fired for erosion and during the continuance of the firing it is targeted at 200 yards at the beginning and after each 1,000 rounds have been fired therefrom. Accurate measurements of the diameters of the bore at the breech end are made after each 1,000 rounds have been fired and the bores of many of the barrels are stargaged throughout in addition thereto. The purpose of this is to determine the relation between bore wear at the breech end and the accuracy of the rifle as a function of the number of rounds fired. Much interesting data and many interesting results including some which are anomalous have been obtained. When the investigation is completed it is hoped that it will be possible to draw definite conclusions relative to the probable number of rounds which have been fired from a gun barrel based upon the wear in the breech end of the bore as determined by suitable and simple gages. In addition to firing new barrels, barrels which have been fired varying amounts in the service are being gaged and targeted with a view to comparing the data obtained therefrom with the data obtained in connection with the firing of new barrels.

Heat Treatment and Finish of Small Arms at Springfield Armory

By P. W. Oliver*

THE heat treatments and finishes described in this article will deal principally with those which are given to the components of the U. S. Rifle, caliber .30, Model 1903. The heat treatment for the components of all the other types of caliber .30 rifles, manufactured at Springfield Armory is the same as for the service type. Some of the components of the U. S. Rifle, caliber .30 are interchangeable with those of the U. S. Rifle, caliber .22, Model 1922 MI. All these interchangeable components are given the same heat treatments.

The finish applied to the metal components of the different types of rifles varies according to the service to which the rifles will be put. For instance, the barrel and receiver of the sport type is given a finish which has a better appearance, but not as durable or rust-resisting as that given to the service rifle. The different kinds of finishes applied to the metal components of all types of small arms will be described in the latter part of this article. The finish applied to the components of cleaned and repaired rifles differs slightly from that applied to new components.

A brief description of the various terms used in heat treating is given in order that there may be no misunderstanding as to what is meant by the term where it is used in this article.

Heat treatment[1]: An operation or combination of operations involving the heating and cooling of a metal or alloy in the solid state. This is for the purpose of obtaining certain desirable conditions or properties. Heating and cooling for the sole purpose of mechanical working are excluded from this definition.

Quenching: Immersing in liquids, gases, or solids for the purpose of cooling.

Hardening: Heating and quenching certain iron base alloys from a temperature either within or above their critical temperature range.

Annealing: Heating and cooling of a material in the solid state. It usually implies a relatively slow cooling.

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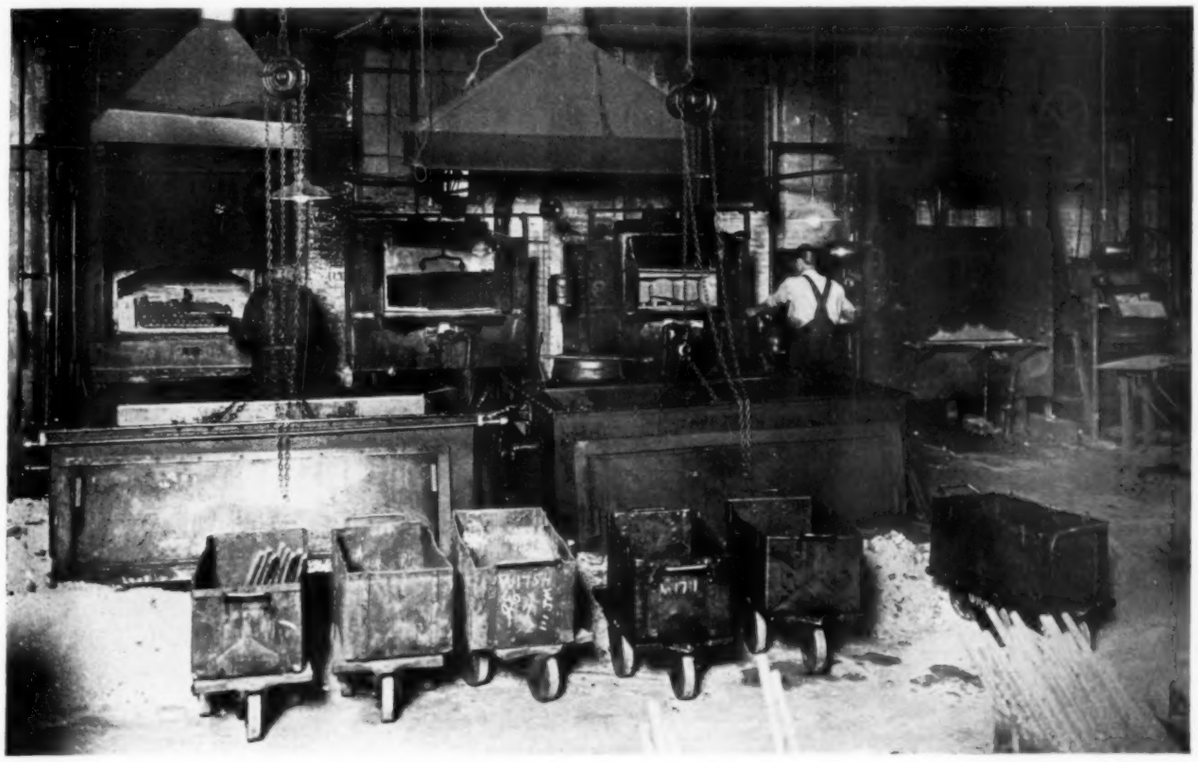
1A. S. S. T. Handbook, p. 107-109 incl.

TABLE I

		Carbon	Manganese	Max. Phos.	Max. Sul.	Nickel.
Carbon Steel	W. D. 1020	.15- .25	.30- .60	.045	.050	
Carbon Steel	W. D. 1095	0.90-1.05	.25- .50	.040	.050	
O. H. Screw Stock	W. D. 1120	.15- .25	.60- .90	.060	.075-1.50	
Manganese Steel	W. D. 1325	.20- .30	1.00-1.30	.050	.050	
Manganese Steel	W. D. 1350	.45- .55	1.00-1.30	.050	.050	
Nickel Steel	W. D. 2340	.35- .45	.50- .80	.040	.050	3.25-3.75

Component	Steel	Component	Steel	Component	Steel
Barrel	W. D. 1350	Firing Pin Sleeve	W. D. 1120	Safety Lock Spring	Music Wire
Base Pin	W. D. 1095	Fixed Base	W. D. 1120	Safety Lock Thumb Piece	W. D. 1020
Base Spline	W. D. 1095	Fixed Stud	W. D. 1120	Sear	W. D. 1020
Base Spring	W. D. 1095	Floor Plate	W. D. 1120	Sear Pin	W. D. 1120
Bolt	W. D. 1325	Floor Plate Catch	W. D. 1120	Sear Spring	Music Wire
Bolt Stop Pin	W. D. 1120	Floor Plate Pin	W. D. 1120	Sleeve	W. D. 1120
Bolt Stop Spring	W. D. 1095	Floor Plate Spring	Music Wire	Sleeve Lock	W. D. 1120
Butt Plate	W. D. 1120	Follower	W. D. 1120	Sleeve Lock Pin	W. D. 1120
Butt Plate Cap	W. D. 1120	Front Sight	W. D. 1095	Sleeve Lock Spring	Music Wire
Butt Plate Pin	W. D. 1120	Front Sight Pin	W. D. 1095	Slide	W. D. 1120
Butt Plate Screws	W. D. 1120	Front Sight Screw	W. D. 1120	Slide Binding Screw	W. D. 1120
Butt Plate Spring	W. D. 1095	Guard	W. D. 1120	Slide Cap	W. D. 1120
Butt Plate Spring Screw	W. D. 1120	Guard Screw Bushing	W. D. 1120	Slide Cap Pin	W. D. 1095
Butt Swivel	W. D. 1120	Guard Screw Front	W. D. 1120	Slide Cap Screw	W. D. 1120
But Swivel Pin	W. D. 1095	Guard Screw Rear	W. D. 1120	Stacking Swivel	W. D. 1120
Butt Swivel Plate	W. D. 1120	Hand Guard Clip	W. D. 1095	Stacking Swivel Screw	W. D. 1120
Butt Swivel Screws	W. D. 1120	Joint Pin	W. D. 1120	Stock Screw Front	W. D. 1120
Cocking Piece	W. D. 1120	Leaf	W. D. 1120	Stock Screw Rear	W. D. 1120
Cut Off	W. D. 1120	Lower Band	W. D. 1120	Stock Screw Nuts	W. D. 1120
Cut Off Plunger	W. D. 1120	Lower Band Screw	W. D. 1120	Striker	W. D. 1095
Cut Off Screw	W. D. 1120	Lower Band Spring	W. D. 1095	Stud Pin	W. D. 1095
Cut Off Spindle	W. D. 1120	Lower Band Swivel	W. D. 1120	Trigger	W. D. 1020
Cut Off Spring	Music Wire	Magazine Spring	W. D. 1095	Trigger Pin	W. D. 1095
Drift Slide	W. D. 1120	Main Spring	Music Wire	Upper Band	W. D. 1120
Drift Slide Pin	W. D. 1120	Movable Base	W. D. 1120	Upper Band Screw	W. D. 1120
Ejector	W. D. 1020	Movable Stud	W. D. 1120	Windage Screw	W. D. 1120
Ejector Pin	W. D. 1120	Receiver	W. D. 1325	Windage Screw Collar	W. D. 1120
Extractor	W. D. 1095	Receiver (New)	W. D. 2340	Windage Screw Knob	W. D. 1120
Extractor Collar	W. D. 1120	Safety Lock Plunger	W. D. 1095	Windage Screw Spring	Music Wire
Firing Pin Rod	W. D. 1095	Safety Lock Spindle	W. D. 1120		



Annealing Furnaces, Water Shops Plant, Springfield Armory.

Normalizing: Heating iron base alloys above their critical temperature range followed by cooling below that range in still air at ordinary temperature.

Tempering (also called drawing): Reheating after hardening to some temperature below the critical range followed by any rate of cooling.

Carburizing: Adding carbon to iron base alloys by heating the metal below its melting point in contact with carbonaceous material.

Case hardening: Carburizing and subsequent hardening by suitable heat treatment, all or part of the surface portions of a piece of iron base alloy.

Case: That portion of a carburized iron base alloy article in which the carbon content has been materially increased.

Core: That portion of a carburized iron base alloy article in which the carbon has not been materially increased.

Cyaniding: Surface hardening of an iron base alloy article or portion of it by heating to a suitable temperature in contact with a cyanide salt, followed by quenching.

The rifle is composed of ninety-one metal parts, thirty-four of which do not receive any heat treatment, while the remaining fifty-seven are heat treated in order to produce in them better physical qualities. Thirty-one of the metal components are forged from the bar stock. After being forged the parts are annealed to relieve them of any rolling or forging strains. The parts are then machined and after the finished machining operations they are hardened and tempered. The different types of hardening which are used are carburizing, cyaniding and open-fire hardening.

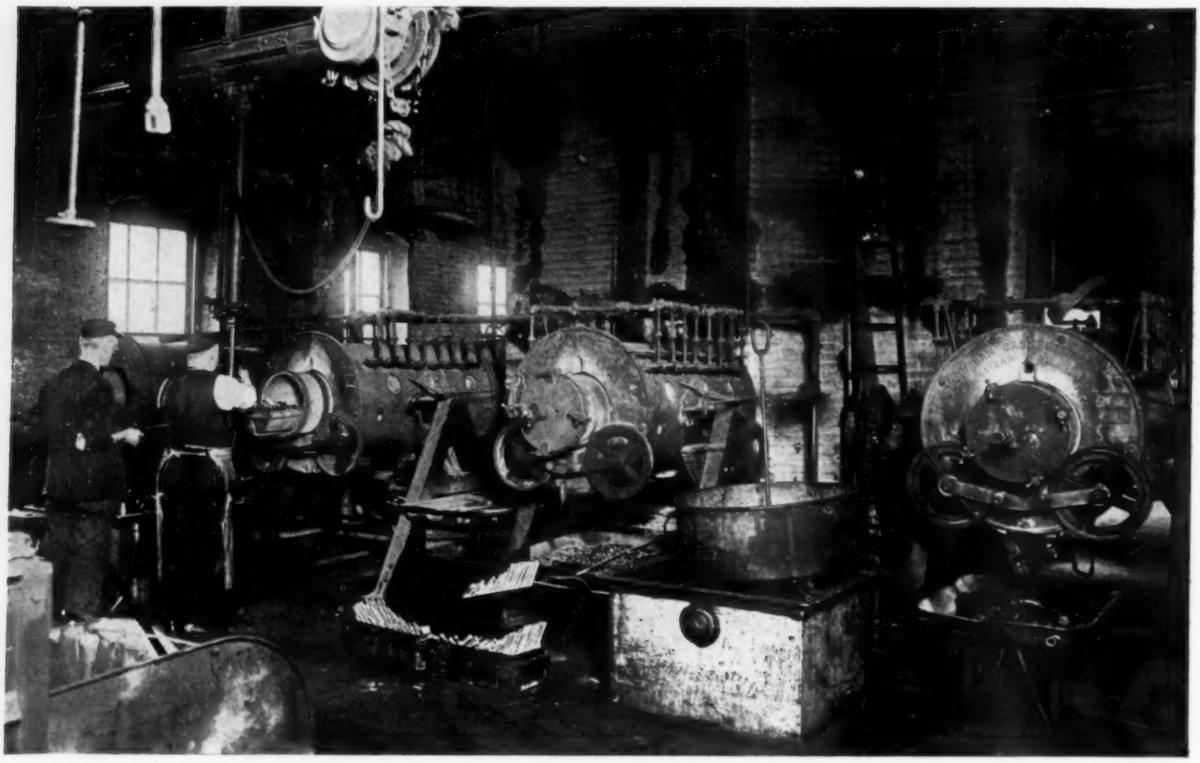
TABLE I is a list of the metal components of the service rifle together with the class of steel used in these components. For Ordnance Department steels[2] the numerical index system developed by the Society of Automotive Engineers has been followed, which makes it possible to use on shop drawings and blue prints specification numerals that are partially descriptive of the material covered by the numbers.

The first figure indicates the class to which the steel belongs; thus "1" indicates a carbon steel; "2," a nickel steel; "3," a nickel-chromium steel. In the case of alloy steels, the second figure generally indicates the approximate percentage of the predominant alloying element. Usually the last two figures indicate the average carbon content in "points" or hundredths of one per cent. Thus "W. D. 2340" indicates a nickel steel of approximately three per cent. nickel (3.25-3.50) and .40 carbon content (0.35-0.45).

All the forging and annealing operations at Springfield Armory are carried on at the Water Shops plant. The annealing department is adjacent to the forge shop so that no time is lost in moving components after they have been forged.

The annealing furnaces are of several sizes and designs. For quantity production there are available four Small-wood furnaces, each of which will hold four pots. The pots are placed on stringers which in turn are placed on round iron balls. The stringers and balls are pushed into the furnace and heated. The chamber of the furnace is divided into two sections, one section for heating and the other section for cooling. When the work has been held at the annealing temperature for the proper length of time the door between the two sections is raised and the pots are pulled into the cooling section, the door is lowered and the heating chamber is ready for another load to be heated for annealing. By the time the second load has been held at the annealing temperature for the proper length of time

[2]Ordnance Dept. Document No. 5050.



Furnaces Used to Carbonize Rifle Components, Springfield Armory.

the first load has cooled sufficiently to be removed from the cooling chamber and unloaded. In this way no furnace time is lost.

For small quantities of work there are available four semi-muffle-type furnaces of the usual design. Oil is used as a fuel for heating these furnaces. It is piped to the furnace under 15 pounds pressure. Air is piped to the furnace at one and one-half pounds pressure.

The furnaces are arranged in groups of three or four furnaces to a group. Each furnace has its own thermo-couple or thermo-couples which lead to a group pyrometer. By means of a selective switch the operator can record on the pyrometer the temperature of any desired furnace in that group.

The components which have been forged from the bar stock (as listed in Table II) when sent to the annealing room are placed in pots with charcoal and the pots are covered and sealed with fire clay. Components forged from W. D. 1020, W. D. 1120, W. D. 1325 steels, are heated to 1500°-1550°F., held at that temperature for two hours and furnace cooled. Components forged from W. D. 1095 steel are packed in pots similar to the others and annealed at 1450°-1475°F. After annealing, the parts are sifted from the charcoal and sent to be pickled.

TABLE II
Components Forged From the Bar Stock.

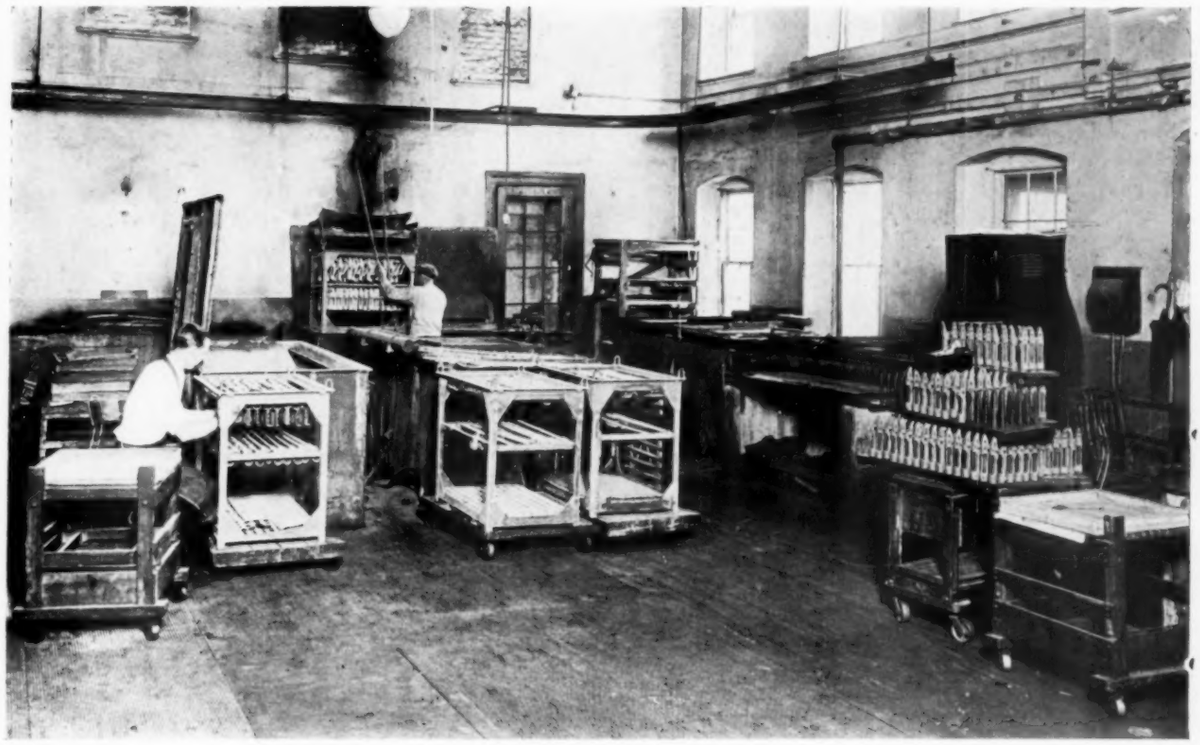
Barrel	Guard
Bolt	Leaf
Butt Plate	Lower Band Swivel
Butt Plate Cap	Lower Band Spring
Butt Swivel Plate	Movable Base
Cocking Piece	Movable Stud
Cut Off	Receiver
Ejector	Safety Lock Thumb Piece
Extractor	Sear
Extractor Collar	Sleeve
Fixed Base	Sleeve Lock
Fixed Stud	Upper Band
Floor Plate	Slide
Floor Plate Catch	Slide Cap
Follower	Stacking Swivel

THE hardening and tempering of the components is done at the Hill Shops. Gas which is used as a fuel for heating these furnaces is supplied by the local gas company. Before going to the furnaces it is run through a Selas gas-mixing machine where it is mixed with air and sent to the furnaces under a constant pressure. Not enough air is mixed with the gas to form an explosive mixture but enough is added so that compressed air is not necessary at the burner. By means of special burners enough air is admitted at the burner to make the proper combustion.

The furnaces are arranged in groups similar to those used in the annealing department for the purpose of temperature recording. In addition to the group pyrometers there is also a recording instrument for those operations which demand the closest adherence to a specified temperature. This recording machine also shows the rate of heating, the variation from the desired temperature and the time held at the desired temperature. The carburizing and tempering furnaces are of American Gas Company manufacture. For carburizing, the carbonizing machine No. 2 is used and for tempering the heating machines type 51 and type 64 are used. Salt bath furnaces and semi-muffle type furnaces of the usual type complete the installation.

For uniform hardening results it is necessary that the oil used in quenching be kept at a constant temperature during the quenching operations. In order to obtain this uniformity a large reservoir tank is situated under ground with water-cooling coils running around the inside of the tank. Oil is pumped from this reservoir tank to the individual quenching tanks, and the overflow from the individual tanks returns to the reservoir tank by gravity. This method gives a continuous flow of cool oil to the individual tanks at all times.

With the exception of the barrel all components are



Parkerizing Tanks and Racks at Springfield Armory.

finished machined before they are heat treated. The heat treatments given to the different components, which will be described in detail, vary according to the physical qualities which are desired in the components. For instance, the receiver must have a hard case to withstand wear and a tough core which will resist shock. The sear must have a thick hard case because it is continually being subjected to wear. In the carburizing operations the depth of the case desired, except in a few instances, is .008-inch.

Barrels are rolled from the bar stock to a rough shape. After rolling, the barrel blanks are normalized at 1650° F. and annealed at 1600° F. for two hours. They are then hardened by heating in an open fire to 1550° F. for one hour and then quenching in oil. They are tempered to meet the following physical specifications:

Yield Point, 75,000 lbs. per sq. in.
Tensile Strength, 110,000 lbs. per sq. in.
Elongation, 20.0 per cent.
Contraction of Area, 50.0 per cent.

The standard .505-inch tensile test specimen is prepared from the breech end of the barrel blank. Each barrel blank is given a Brinell hardness test and must be between 228-269.

When the receivers are sent to the hardening department a plug is screwed into the threaded end and two small plugs are screwed into the guard screw holes. The receivers are placed in an American Gas Company's carburizing machine No. 2 with charred animal bone and heated to 1450° F. for two and three-quarters hours and quenched in oil. They are next heated in a salt bath at 1300° F. for five minutes and quenched in oil. A final temper of 350° F. in an oil tempering bath for one-half hour completes the treatment. One receiver from each lot treated is broken in a vise. From the ease or difficulty with which this receiver is bent or broken an indication is obtained of the toughness of the receiver. A specimen from this broken receiver is examined under the microscope for the depth of case and the structure of the case and core. Each receiver is given a scleroscope hardness test and must be within the limits of 50-60.

The type of steel used in the receiver has been changed recently. Originally it was W. D. 1325, but it is now W. D. 2340 (three and one-half per cent. nickel). The heat treatment for receivers of nickel steel is as follows: heat to 1425-1450° F. for five minutes in a salt bath; quench in oil; temper at 700° F. for one-half hour and air cool. Receivers made of W. D. 2340 steel are tested for hardness on the Rockwell Hardness Testing Machine and must be within the limits of C-40 to C-50.

The bolts are carburized in the same type of furnace as the W. D. 1325 steel receivers. They are heated to 1500° F. and held at that temperature for three hours and quenched in oil. This is followed by heating in a salt bath at 1300° F. for five minutes and quenching in oil. Final treatment consists of tempering in oil at 350° F. for one-half hour and air cooling. One bolt from each lot heat treated is broken in a vise and a section of it examined under the microscope. A scleroscope hardness test is made on every bolt and must be within the limits of 50-60.

Many of the smaller components are carburized in bone at 1450° to 1500° F. and quenched in oil from the carburizing heat. No further treatment is given these components. Table III is a list of components treated in this manner.

TABLE III

Butt Plate Screw Large	Joint Pin
Butt Plate Screw Small	Leaf
Butt Plate Spring Screw	Movable Base
Cut Off (Ejector stop on caliber .22)	Sear (0.12-inch case)
	Sear Pin
Cut Off Spindle	Sleeve
Ejector Pin	Stock Screw Nuts
Floor Plate Catch	Trigger
Follower	Upper Band Screw
Guard Screw Front	Windage Screw Collar
Guard Screw Rear	

The cooking piece is carburized at 1500° F. to obtain a depth of case of .012-inch and oil quenched. This is followed by a second heating in bone at 1300° F. and an oil quench.

The safety lock thumb-piece and the ejector are carburized at 1450° F. for two hours and then quenched in oil. This is followed by a second heating in bone at 1300° F. for one hour and an oil quench.

The parts listed in Table IV are hardened on the surface by heating in a cyanide bath at 1500° F. for five minutes and all are oil quenched with the exception of the safety lock spindle which is quenched in water.

TABLE IV

Butt Plate	Safety Lock Spindle (Cam end only)
Butt Plate Pin	Sleeve Lock
Butt Plate Cap	Sleeve Lock Pin
Cut Off Plunger	Upper Band (Bayonet lug only)
Cut Off Screw	

Table V is a list of those components which are manufactured from W. D. 1095 steel and are hardened by heating in a semi-muffle-type furnace and quenched in oil. After being hardened the parts are tempered in an American Gas Company Heating Machine, type 51 or type 64.

TABLE V

Component	Harden Degrees F.	Temper Degrees F.
Base Pin	1450	700
Base Spline	1450	700
Base Spring	1450	750
Bolt Stop Spring	1450	680
Butt Plate Spring	1450	680
Firing Pin Rod—Front end only	1500	800
Front Sight	1450	700
Front Sight Pin	1450	700
Hand Guard Clip	1450	700
Safety Lock Plunger	1450	700
Slide Cap Pin	1450	700
Striker	1450	700
Stud Pin	1450	700
Trigger Pin	1450	700
Extractor	1550	800

The lower band is first annealed and bent to final shape, then heated to 1450° F., oil quenched and tempered at 750° F.

THERE are four types of finishes used on the various components. They are, parkerizing, oil blackening, niter blueing and browning. Parkerizing is a chemical process which changes the surface of the iron or steel to an insoluble phosphate. This is highly resistant to rust. Parkerizing is a patented process, the patents being owned by The Parker Rust Proof Company at Detroit, Michigan.

Parkerizing is used as a finish for the barrel, bolt, extractor, guard, floor plate, butt plate, butt swivel assembly, upper band and receiver. The method followed is, first, to clean the parts very thoroughly by washing in a soda solution. This is followed by rinsing, pickling in hot sulphuric acid (10 per cent.) and a second rinsing in hot water. Except for the barrel, the components are sand blasted. The barrel is sand rubbed. After the sand blast or rub, the components are placed on racks and immersed in the parkerizing solution. At first there is considerable hydrogen gas given off. When bubbles stop the work has been processed. It takes approximately one and one-half hours to process the work. The components are then removed from the processing tank and rinsed in clean, boiling water.

Oil Blackening is done in two ways at Springfield Armory. The first is by heating in bone to 1300-1500° F. and quenching in oil. If held too long or if an excess amount of air comes in contact with the work a scale will form on the components. The second method is to dip the components in oil and place in an American Gas Furnace Heating Machine Type 51 which has been heated to approximately 650° F. They are held at 650° F. for about one-half hour and then quenched in oil. This method is not applicable to heavy parts that will be apt to get nicked or scratched in tumbling.

Niter Blueing is done in a pressed steel pot which contains a mixture of nine parts of sodium nitrate to one part of manganese dioxide. This mixture is heated to at least 680° F. The temperature used for blueing is varied for different components depending on what previous heat treatment, if any, they have had. The range of temperature is from 680° to 950° F. The work is placed in wire baskets and is immersed in the molten niter until the desired blue color is obtained. The time for blueing is approximately five minutes. When the desired color has been obtained the components are quenched in cold water to set the color. To get rid of any adhering niter the parts are next immersed in boiling water. This is followed by an oil dip. There are many variations from the above method and bath mixtures which will give the desired blue color.

Browning: There are many processes for browning[3] steel. The matter, however, may be summarized by describing one process, in spite of numerous variations, chiefly in the composition of the browning solutions. Other variations occur in the manipulation and in the atmospheric conditions, artificial or natural.

The articles are first thoroughly cleaned by boiling in a soda solution and then dried by placing on a draining rack. When cooled to approximately 120 degrees Fahrenheit, they are coated with the browning solution. The browning solution is applied evenly over the surface of the article with a brush, a sponge or by dipping. The parts are dried for approximately thirty minutes, a second coat of the solution is applied and then dried for thirty minutes more.

The articles are then placed in a warming room and brought to temperature which may vary from 140° up to as high as 175° F. Dry heat is satisfactory, as it is its function merely to bring the article up to a temperature such that when it is placed in the humidor rusting cabinet, dew will not form on the surface, causing spots.

The time in the warming room will naturally vary according to the size of the piece. The parts are then transferred from the warming room to the rusting room. This must be at the same temperature as the warming room (175° F.). Humidity up to the saturation point is desired, but danger of condensation should be avoided, as pitted and spotted work will result if the dew point is reached. Articles are rusted in approximately one hour and thirty minutes.

The rusted metal, now a dirty greenish red, is removed from the humid room to a third cabinet or room, although this is not necessary. The conditions are the same as in the first room. The object is to set the rust. The rusted metal is allowed to remain in this room for thirty minutes. Then the articles are placed in clean boiling water for fifteen minutes. They are allowed to drain dry, and are then carded on a wire brush or fiber wheel, which removes any loose particles of oxide on the surface.

After the first coat, two more rustings are applied in substantially the same manner, after which the browned surfaces are given a thin coating of white slushing oil.

3A. S. S. T. Handbook A95-A96.

Fig. 1. Cartridge Cases and Primers Removed from Shattered Rifles.

The Bursting of Rifles in Service

By A. L. Woodworth*

THE object of this paper is not to enter into a scientific discussion of the causes of burst rifles but to give a few simple rules for the investigation of burst rifles which will often result in an immediate determination of the cause by an examination of the evidence at hand and prevent further serious trouble.

That there is a need of a more careful examination of burst rifles is very evident from the correspondence received on this subject at Springfield Armory. There is seldom, if ever, definite information that is of help at all in determining what caused the trouble.

The first and most important thing to examine is the ammunition—particularly the fired case in the rifle at the time of the explosion. It was discovered in experimental work on the 1903 model rifle in 1902 that the unsupported rimless head of a cartridge gave entirely different results from the old rim case which was entirely inclosed by the chamber. It was also noted at that time that the head of the case after firing was a very fair gauge of the amount of pressure developed, and in many cases the fired case gave positive indication as to what caused high pressure.

The primer in a rifle case developing normal pressure, 48,000 lbs., will be convex, at 52,000 lbs. the primer will begin to flatten out and at about 75,000 lbs. will be flattened back on a line with the case head. At this pressure primers

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Fig. 2. A Rag left in the Barrel near the Muzzle End did this.

may extrude through the striker hole allowing an escape of gas through the action or leakage around the edge. The case will also show swelling around the head just below the extractor groove. This escape of gas to the rear often causes the shooter considerable inconvenience but does not as a rule injure the rifle in any way providing the rifle is properly assembled.

Often times reports have been received at Springfield Armory of rifles bursting. Investigations were made immediately only to find that an escape of gas of this kind had occurred and that the rifle was not at fault or the barrel, receiver or bolt injured. At about 98,000 lbs., which is the maximum pressure that can be developed with the regular powder and bullet used in this cartridge, the primer pocket opens up and the case head swells out allowing a violent escape of gas through the action that causes considerable trouble to some parts of the rifle but does not shatter the barrel, receiver or bolt providing it is of properly heat-treated steel. The damage in this case usually consists of a shattered stock, blown off extractor and bulged magazine and floor plate. In this case as in the first we do not agree with the reports that have been often sent in that the rifle has burst.

Fig. 3. Rifles shattered by bullet obstruction in the barrel.

At around 124,000 lbs. pressure obtained by using a quicker burning powder the head of the case is completely blown off. This pressure is about the limit that the 1903 model rifles will stand and will in most cases burst the rifle. Either the barrel, receiver or bolt or all three are quite likely to be shattered. To develop this pressure it was found necessary to use a powder that burned so quickly that a very high pressure was developed before the case head—the weakest point—gave way, otherwise the pressure would be released and none of the important parts of the rifle would be fractured.

Frequently, rifles are fired with grease in the barrel. The cartridge case when removed from the rifle will be fluted at the forward end of the first cone (illustration 7, Fig. 1). If the bullet has excessive pull, as in 1921 Frankford Arsenal National Match ammunition, and there is oil or grease in the chamber the case will have the appearance of that shown in illustration 11, Fig. 1. Grease in the barrel causes very high pressure and in addition the case, instead of gripping the chamber and helping to take up some of the shock, will slip and allow all the pressure to be taken up by the bolt.

The damage to the rifle depends on the amount of grease in the barrel and its location. If there is considerable grease near the bullet seat the bolt and receiver are ruined and the stock and other parts shattered. There is seldom any injury to the barrel. If the grease is in the forward end the cartridge case is fluted and the base shows high pressure only. The barrel is bulged but the receiver or other parts of the rifle are not injured.

Defects in the steel of the barrel, such as inside seams or burnt steel, often can be detected by an examination of the cartridge case. A seam will leave a raised line on the case usually longitudinally. Illustration 8, Fig. 1, shows a case split out by a high pressure cartridge of 75,000 lbs. in the chamber of a rifle that had been sent in for examination after marks indicating a seam had been discovered on the case. This rifle was burst by the high pressure charge and would eventually have burst with service ammunition.

Raised blisters, usually on 2nd or 3rd cone, are an indication of burnt steel. A close inspection is necessary to discover this.

Examination of the case left in a rifle after it has burst, even though a very small section is left, very often will show that the wrong ammunition has been used. Illustration 8, Fig. 1, shows a German case found in a burst rifle. The bullet of this German cartridge is so large that it is difficult to chamber in a new rifle but will chamber in a rifle with a worn barrel without much trouble. The neck of the German case is shorter than the 1906 case and has crimp marks around the neck different from any manufactured in the United States. In all known cases the rifle has been completely shattered by the German cartridge. A case ruptured about a quarter of an inch from the extractor groove is indicative of excessive head space.

Punctured primers, as in illustration 12, Fig. 1, where there are no indications of high pressure usually show that the striker hole is too large. A soft cartridge case that has in some way been allowed to get in with the regular cases will expand at the head considerably and cause trouble with a normal load of powder. The case head will have the appearance of too much pressure but the results will not be the same. There will be no evidence of excessive pressure on the locking lugs or elsewhere and the only damage to the rifle will result from escaping gas through the

mechanism. Soft cases have been blamed in the past for many burst rifles. This, however, could not be proved. Tests in the past and recently with cases annealed so soft that the bullets would hardly stay in the case conclusively proved that no material damage would result to the rifle from firing them.

NEXT to the ammunition it is important to examine the barrel of the rifle for evidence of what caused the trouble. Obstructions in the barrel of the rifle have caused more burst rifles than anything else. It is often possible to tell what the obstruction was by an examination of the bore.

Patches or rags or cleaning material head the list of obstructions. A patch does not always cause trouble: sometimes it is blown out without doing damage. It always seems, from an examination of a barrel that has been burst from such obstruction, that the point of the bullet catches in the rag and, due to the rifling, winds around the rag and wedges the barrel apart on one side. The barrel always has a twisted appearance and the primary bulge is always greater on one side.

The damage to the rifle depends on the amount of rag and its location in the barrel. An oily rag will cause more trouble than a dry rag. A rag of considerable size near the chamber will occasionally cause excessive back pressure, expand the case head and often wreck the action. If the rag is in about the middle of the barrel there will be a bulge in the barrel but no other damage. If the rag is near the muzzle end the barrel shows a slight bulge although this has been known to split the barrel. A typical case is shown in Fig. 2. In this case a piece of burnt rag was driven into a crack made by the explosion.

A BULLET in the barrel will cause a very even ring entirely around the barrel at the lower end. If the bullet is within an inch of the forward end of the chamber the rifle is completely shattered. If in the center of the barrel a bulge occurs; if near the muzzle the barrel is split, sometimes in several places. Two very good examples are shown in Fig. 3.

Mud or grease in quantity in the muzzle give about the same results. The bulge, however, is not as abrupt at the lower end but tapers out. If there is any considerable quantity of grease or mud throughout the barrel the rifle is nearly always completely shattered. A typical example is shown in Fig. 4. If the barrel is obstructed in the rear end it seems to make little difference whether the receiver is of the old heat treatment or the new except that in the latter case the receiver does not shatter but merely bulges and sometimes splits. In any case the rifle is ruined.

Failures from defective material are not frequent and it is difficult to give rules for the inspection of the steel. It is well always to scrutinize the parts at the point of the breech. Sometimes defects are very noticeable as in the case of seamy or burnt stock. On a few occasions burst rifles have been returned that were thought to have been ruined because the bolt was not completely closed, but in all cases examination of the bolt lugs and receiver shoulders showed that the bolt was fully closed.

When a burst rifle is received at Springfield Armory it is first carefully examined and notes made of all broken or injured parts. If there is a fired case in the barrel, as is almost always the case, it is removed and examined and the bore of the barrel is carefully scrutinized for bulges or breaks. The rifle is then dismounted and parts examined carefully.

Fig. 4. Mud or grease in quantity in the barrel was responsible for this.

As an illustration, a diagnosis of rifle No. 821014 is given:

Receiver: Locking shoulders set back .018-inch. Rear right side upset. Safety lug shows good stretch.

Bolt: Shattered. Handle, both locking lugs and extractor broken off. Bolt broken in two, no stretch. Steel at point of break clean but coarse.

Barrel: Slight bulge about eight inches in from breech.

Cartridge Case: Head three-quarters brown off. Second cone fluted on case.

Stock: Shattered.

In this case the bolt was examined by the Metallurgical Department at Springfield Armory and the pressure of the ammunition being used at that time was taken. The rifle, as the diagnosis shows, was burst by an obstruction of grease in the barrel.

Thus it may be set down as a cardinal rule: Be sure of the ammunition and certain of the condition of piece. The examples cited in this article indicate beyond peradventure that the "wrong" ammunition—a condition for which the rifleman is not so much to be blamed—and the presence of the lowly cleaning rag and grease—a condition for which the rifleman is entirely responsible—are the most common causes of the bursting of rifles in service.

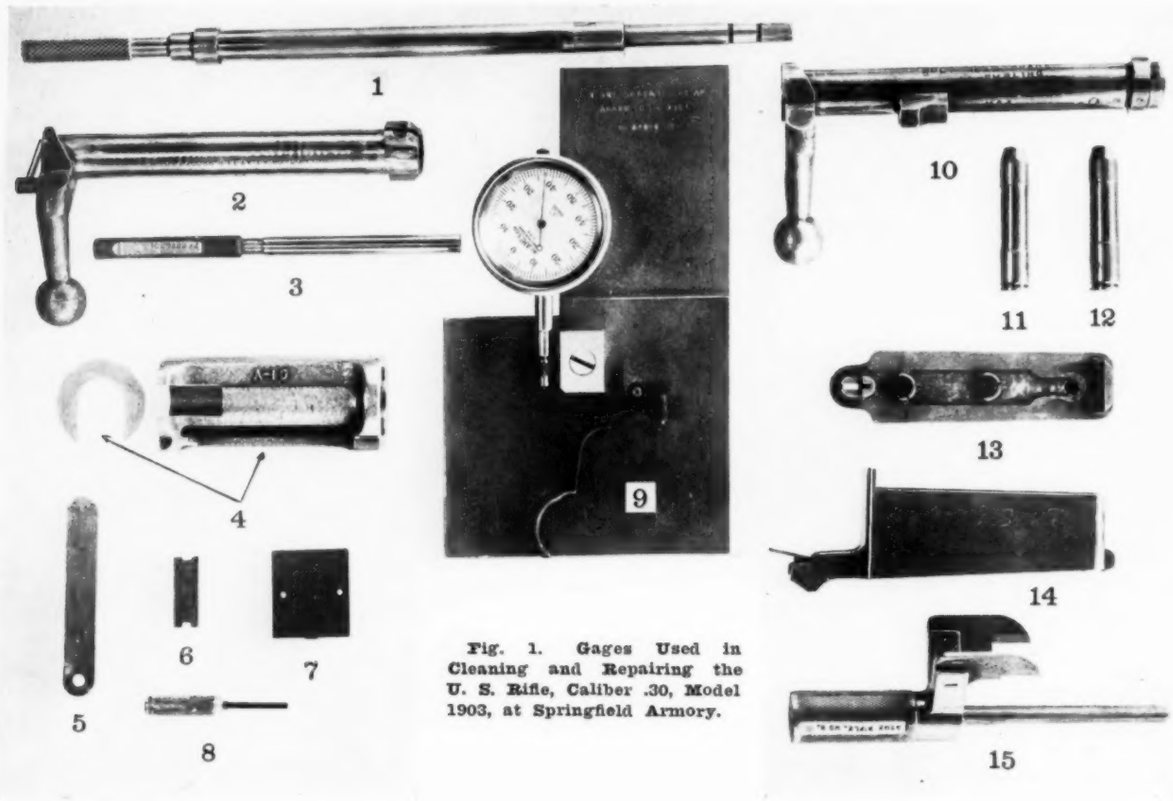

Fig. 1. Gages Used in Cleaning and Repairing the U. S. Rifle, Caliber .30, Model 1903, at Springfield Armory.

Overhauling the Service Rifle

By Lieut. J. E. McInerney,* Ord. Dept., U. S. A.

MAN'S first weapons were such that the question of repairs was of minor importance. It was not until after the discovery of gunpowder, which brought about the use of firearms, that he was confronted with the problem of keeping his weapons in continual repair. He soon realized that unless his firearm was in good condition it would be a means of self-destruction rather than a means of protection. As rifles of greater power and accuracy came into use it became apparent that the effectiveness of the weapon depended, among other things, upon the care given it. And when we realize that the rifle in present use is a mechanism which must function with a pressure of 75,000 pounds per square inch developed in its chamber, we can see the necessity for its complete overhaul when the inevitable signs of wear begin.

The greatest single development which helped to simplify the problem of repair was the introduction of interchangeable rifle manufacture at Springfield Armory in 1842. This method of manufacture was introduced by Captain John Hall in making a new percussion musket. By the time the present model of rifle came into being in 1902, interchangeability of parts had been well established. The impossibility of the present methods of cleaning and repairing the service rifle without this interchangeability of parts will become evident after we have examined the procedure at Springfield Armory.

In this article I shall endeavor to cover in detail the procedure now being followed at Springfield Armory for the complete renovation of the service rifle.

We might first take a hurried glance at the limiting factors which determine how extensive this overhaul will be. The first of these may be considered as the demands of the using services. In these days of high standards of qualification in rifle marksmanship, organization commanders have every right to demand rifles which are as accurate and as smoothly operating as can be made. Every effort is made to turn out a cleaned and repaired rifle which is as satisfactory as a new rifle. But the amount of work that can be done on these rifles is limited by the second factor, the funds available for this kind of work. The problem when funds are limited is whether it would be better to spend all the money for the overhaul of, let us say, 10,000 rifles or to make the overhaul less extensive and clean and repair about 20,000 rifles. By improving shop methods and by eliminating unnecessary operations it has been found that about 2,500 rifles a month can be overhauled without lowering the standard of work. In the number of operations an attempt has been made to reach a condition of marginal effectiveness, that is, where additional operations would increase the effectiveness of the rifle to such a

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small extent that they are not worth the extra expense involved.

The general procedure in overhauling the rifle may be divided into the following seven groups of operations: Disassembly and separation of components; inspection of components; repair and refinish of components; reassembly of rifle; proof firing and function firing; bore sighting; final inspection. This outline will be followed to describe in detail the different operations which are necessary in cleaning and repairing the rifle.

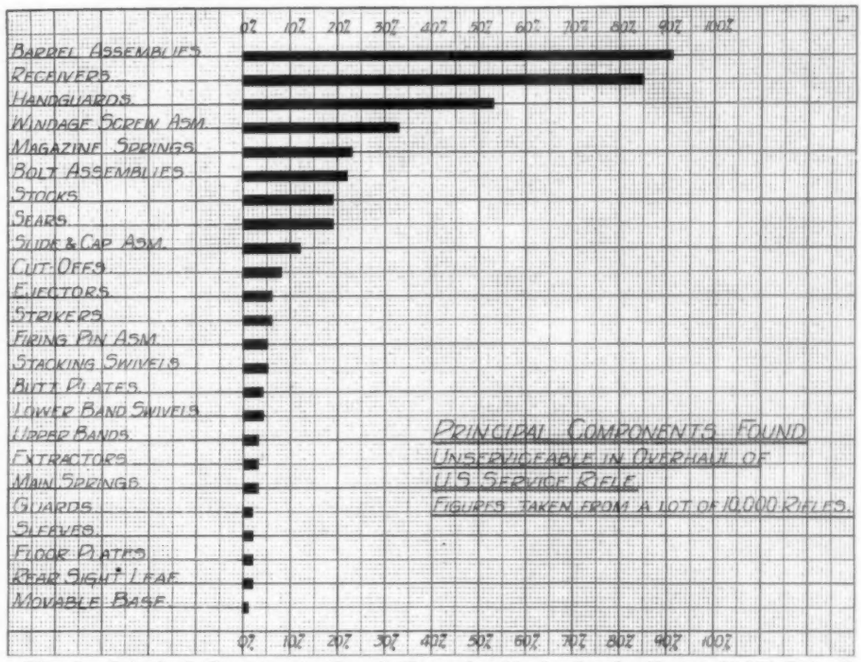


Fig. 2. Principal Components Found Unserviceable in Overhauling a 10,000 Lot of U. S. Service Rifles.

ALL service rifles sent to Springfield Armory to be cleaned and repaired are put through the same process and it has been found necessary to disassemble completely all of these rifles, which because of some major defect have become unserviceable. Before being taken down the rifles must first be cleaned of the heavy coating of grease. This is just a rough cleaning and is done because it makes the disassembly easier. The bolts are removed from the rifles, washed separately and the stock, barrel and action assembly are cleaned as a unit. The cleaning consists of immersing the parts in a tank of gasoline and scrubbing with a bristle brush. The bolt is stripped leaving the sleeve as an assembly. The handguard and stock are removed from the barrel, the handguard clips removed from the handguard and all metal parts, except the stock screws and the guard screw bushings, are removed from the stock, the butt plate and cap remaining as an assembly. The remainder of the rifle is torn down, leaving the following as assemblies: upper band, lower band, rear sight, front sight movable stud and front sight, trigger and sear, and windage screw. The barrel is not removed from the receiver. The rear sight is partly disassembled leaving the following parts as an assembly: base spring, movable base, joint pin and leaf. All the metal parts are then washed in a hot solution of soda and are in a condition to be inspected.

Fig. 3. Disassembling the Service Rifle Prior to Overhauling at Springfield Armory.

In the operations described above all the different components and assemblies are kept separated upon being disassembled, so that after being washed they are counted and are ready to be inspected.

IT WILL be noticed that in the disassembly operations a number of minor assemblies are not taken down. All these can be inspected in the assembled condition.

All parts are given a visual inspection and the functioning parts on which the wear is greatest are gaged. The following are the gages used for this work (Fig. 1): (1) Bullet seat gage used

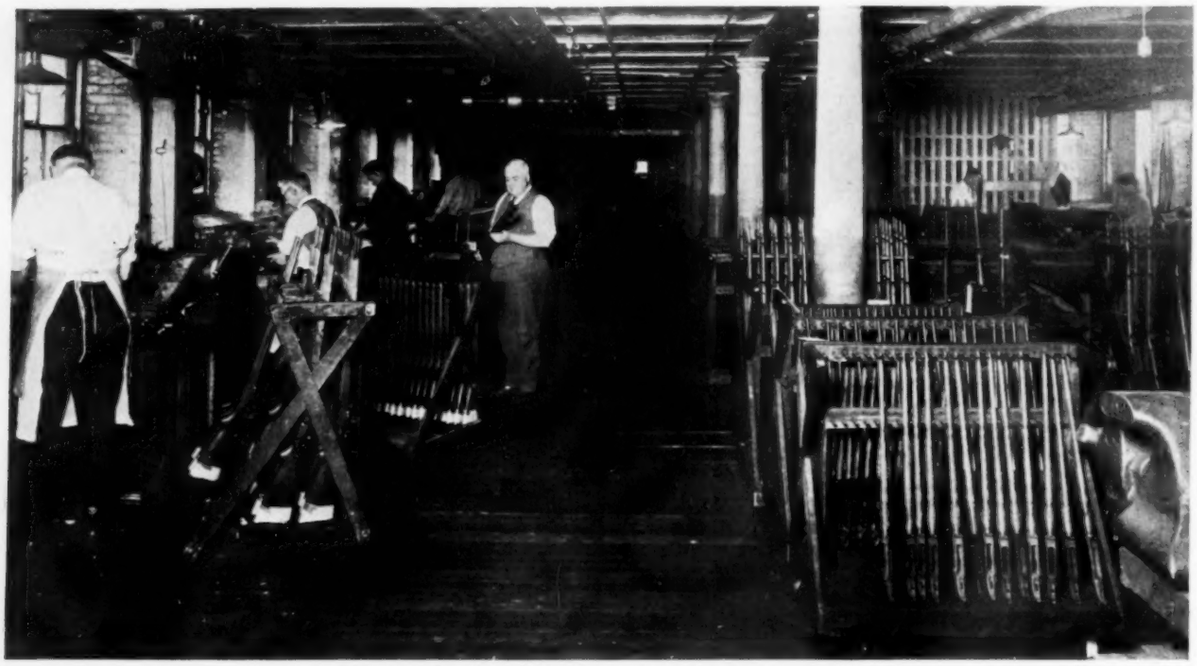


Fig. 4. The Assembly Room at Springfield Armory.

with bolt gage as guide. (2) Bolt which is used as a guide for bullet seat gage. (3) Plug gage for muzzle of bore .302-inch. (4) Gage for measuring headspace of bolt, that is distance from rear of locking lug to face of bolt. (5) Thickness gage .004-inch for measuring clearance between rear of safety lug and shoulder on receiver. (6) Striker projection gage. Measures projection of striker beyond the face of the bolt when the firing pin assembly is all the way forward. (7) Gage for measuring lateral projection of front sight movable stud. (8) Gage for measuring size of striker hole. (9) Gage for measuring height of sear when assembled to the trigger. (10) Minimum bolt to be used with headspace gages. (11 and 12) Maximum and minimum headspace gages 1.946-inch and 1.940-inch. (13) Floor plate gage for testing guard. (14) Guard gage for testing floor plate. (15) Gage for measuring height of front sight.

All parts which are found to be defective and which cannot be repaired as well as all parts which are so badly rust-pitted as to affect the appearance of the rifle are rejected. Screws are condemned if the slot is badly upset or if the threads are stripped or otherwise damaged. Springs which have lost their tension are not used again. All components which are rejected are considered unserviceable and are scrapped. Fig. 2 gives some idea of the number of the principal parts which are replaced. These figures have been taken from a lot of 10,000 rifles which have been cleaned and repaired. The reason for the high percentage of receivers which are replaced will be explained later. It will be seen that 91 per cent. of the barrels are found unserviceable. This figure is not high when it is realized that all rifles which come to an arsenal for repair have been carefully inspected and rejected in the field and that most of the rifles have been found unserviceable because of defective barrels. Also many barrels which might be considered as serviceable by an inspector in the field are rejected when the rifle is overhauled at an arsenal. The standards of arsenal inspection are necessarily higher than those of the field. In the field an inspector might say that the bore of a barrel was pitted but the rifle could be used another year, whereas, at an arsenal the same barrel would have to be condemned on the grounds that it would not be worth assembling it to serviceable parts to be returned again in a year for complete overhaul. When a rifle has been overhauled at an arsenal it should be in such a condition that it can be stored for many years and still be serviceable. It is well known that the corrosive action in pitted barrels will continue even though the bore is heavily coated with grease. It is therefore readily seen that the standard of inspection for the barrel must be high.

The detailed description of the inspection of all the minor components would be of little interest and therefore only the inspection of the following components will be described: barrel and receiver assembly; bolt mechanism; sear and trigger; the sights; stock and handguard.

THE barrel and receiver are inspected in the assembled condition. All Springfield Armory receivers with numbers under 800,000 and Rock Island Arsenal receivers with numbers under 285,507 are removed from the barrels and scrapped. This accounts for the high percentage of rejected receivers as shown in Fig. 2.

It has been found that the heat treatment which was given these low numbered receivers did not render them sufficiently strong and ductile to be satisfactory under abnormal pressure conditions. It was not until 1917, when ammunition was manufactured in large quantities and when troops of uncertain training and experience

were using rifles, that opportunities for accidents, due to faulty ammunition and excessive headspace, became great. Under normal conditions these receivers had been found satisfactory but as soon as there was a departure from the normal it was found that they were too near the allowable safe limit. The present method of heat treatment gives a receiver a very hard surface that will resist wear and a soft, tough core which will resist shock. The present receiver when ruptured will not shatter as did the old one due to its brittle condition. Pressures as high as 133,000 pounds per square inch have been developed in the new receivers without rupturing them.

Fig. 5. Assembling Barrel to Receiver, U. S. Service Rifle.

The receivers which are not rejected for low numbers are inspected for cracks, breaks, burred threads in the guard screw holes and for broken guard screws in the guard screw hole. The barrel and receiver are inspected for headspace, using a master bolt of minimum gage which must not close on a 1.946-inch cartridge gage. If the headspace is excessive the receiver is removed from the barrel and used with a new barrel and the depth of the chamber of the old barrel is gaged to see if that was the cause of the excessive headspace. If the chamber is too deep the barrel is rejected but, if not, then it is assembled to a new receiver, provided it is satisfactory otherwise.

The receivers which are rejected are removed from the barrels and these barrels together with the barrels from which the receivers have not been removed are inspected. If a .302-inch plug gage will enter the muzzle, if the chamber or bullet seat is too deep, or if the bore or chamber is eroded or rust-pitted the barrel is rejected. In the visual inspection of the bore and chamber it is difficult to set a dividing line between barrels which are to be rejected and those to be saved. There are many grades of pitted barrels, such as slightly pitted, finely pitted, developed pits and badly developed pits. When the stage of developed pits is reached the barrel is rejected. The barrel assembly is inspected for loose fixed bases and for loose or cracked fixed studs and the draw line on the barrel and receiver is checked. When the draw lines are correct it indicates that the extractor cut in the barrel and the extractor cut of the receiver are properly aligned.

When a barrel is rejected from a barrel and receiver assembly the receiver, if it has been accepted, the front sight fixed stud and the rear sight fixed base are removed and if found serviceable are used again on new barrels.

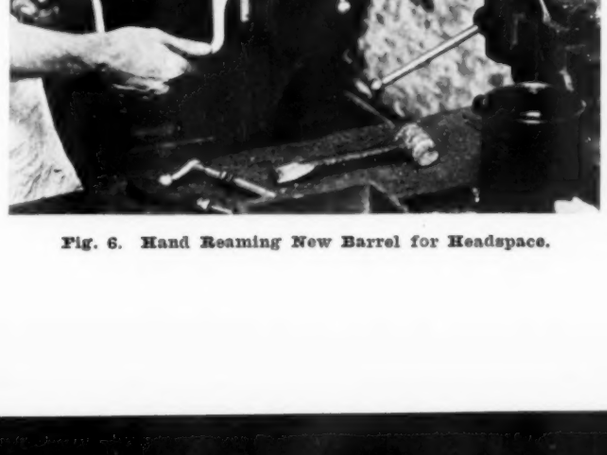


Fig. 6. Hand Reaming New Barrel for Headspace.

BOLTS are first inspected to determine whether they are cracked or broken. If the locking lugs are badly upset or burred the bolt is rejected. The headspace of the bolt, which is the distance from the face of the bolt to the rear of the locking lug, is gaged and must be .507-inch or greater. Bolts used in rifles which have been fired many thousand times or which have been constantly fired with ammunition of higher pressures than are normal generally will show sufficient set-back to cause them to give excessive headspace. The distance from the rear of the locking lug to the rear of the safety lug is gaged and should be less than 3.509 inches. If this distance is too great and the bolt is used with a receiver in which the locking lug recesses are worn the entire shock of the explosion will be transmitted directly to the safety shoulder on the receiver, which, after repeated firing, will cause the receiver to rupture. The striker hole on the face of the bolt should not admit the .085-inch plug gage. The extractor collar must fit freely on the bolt and the extractor is rejected if it is cracked or badly upset on the shell contacts. If the sear notch on the cocking piece shows indications of having been altered, if the nose of the cocking piece is badly upset, or if the safety lock cam on the cocking piece is badly cut or grooved by the safety lock, the firing pin assembly is rejected. The firing pin rod is tested for proper length. Bolt sleeves which are bent, broken, upset or rust-pitted and safety locks with loose spindles, broken or upset plungers are considered unserviceable.

The sear and trigger are inspected as an assembly. They are first given a visual inspection and are rejected if broken, cracked, badly worn or in any way defective. The assembly is then gaged for the height of the sear when it is assembled to the trigger. For this operation gage 9 (Fig. 1) is used. By trying different combinations of sears and triggers satisfactory assemblies are obtained.

Front sight movable studs with front sights attached are inspected and those found serviceable are used again. The front sight screw hole is brazed, the surplus metal is milled off and the assembly is then used on a new barrel.

The movable base, base spring, joint pin and leaf of the rear sight are inspected as an assembly. Parts of this assembly are rejected if badly damaged. The leaf and movable base are straightened if bent. If the windage screw thread on the movable base is burred the base is rejected. Drift slides with .05-inch peep holes are replaced by slides with .06-inch peep holes. The windage screw spring is tested for tension and if the collar does not return to the end of the shoulder on the screw after depressing the assembly is rejected. Windage screws that are bent, worn and those with loose knobs are also considered unserviceable.

Stocks having splits or cracks of such a nature as to render them unserviceable are rejected. Some of the defects found in the stocks which are not due to fair wear and tear are as follows: initials cut in the stock; company numbers stamped in stock; small metal tags tacked on stock and alterations such as making stock similar to sporting stocks. All stocks must be equipped with front and rear stock screws which have been added to the stock to strengthen it in front and rear of the guard. Stocks are tested to see whether they are warped. Under service conditions the stock due to its shape will warp and under extreme weather conditions this warping is aggravated.

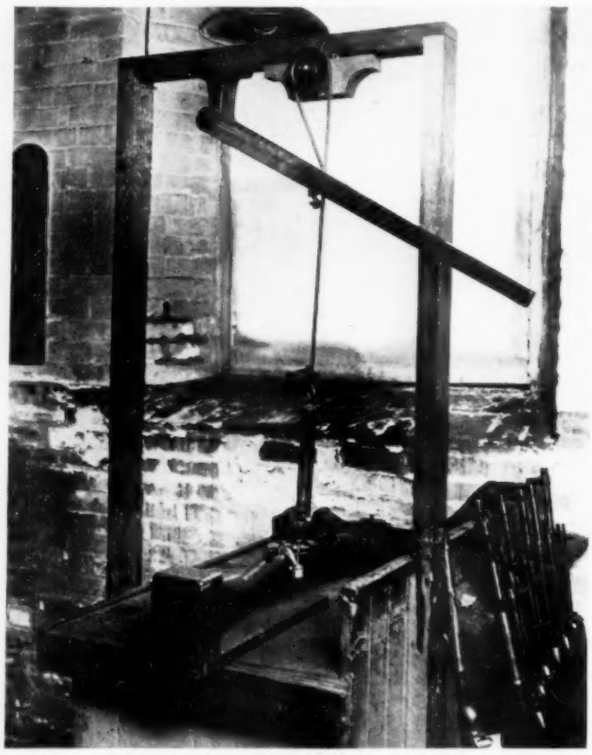


Fig. 7. Bolt-Lift Testing Machine.

Handguards are easily damaged in the service. As is indicated in Fig. 2, over 50 per cent. of the handguards must be replaced on the rifles which are overhauled. Those which are cracked, bruised or in any way damaged are rejected. All handguards must be equipped with two handguard clips.

AFTER inspection components are divided into three groups, those parts which are rejected and are recommended to be scrapped, those parts which are in good condition and those parts which are in need of repairs. Parts in need of repair are repaired and then grouped with those parts in good condition, and all are refinished. Minor assemblies, which are refinished in the assembled condition and which have defective components are taken down, and the defective part is replaced before the assembly is refinished. The repair of the metal parts consists of straightening, reforming, removing burrs, etc. The repairs found necessary on the stock and handguards are the machining operations, which must be done in order to bring the stock up to present specifications, and the patching of sections which have been badly cut or bruised. Small cuts and bruises are filled with shellac or a mixture of shellac and sawdust. The machining operations are profiling the left edge near the receiver, cleaning out the bed for the fixed base and increasing the radius of the groove at the muzzle end of the stock. The last operation makes it possible to have a floating fit between the barrel and the stock and upper band. Where this loose bearing does not exist a small amount of warping of the stock will cause the upper band to bear against the barrel, and as the barrel heats up in firing this bearing will increase, causing the rifle to shoot higher and higher.

Metal components after being repaired are refinished to improve their appearance and to increase their resistance to corrosion. The following components are not refinished: cutoff assembly, floor plate catch and spring, magazine spring, main spring, ejector, follower, trigger and pin, firing pin sleeve, sear and sear pin and striker. The appearance of the rifle would not be improved by refinishing the above components and even when firing most of these parts are covered with a light film of oil.

The most rust-resisting finish is that which is applied by the Parker Process. This consists of forming on the surface of the metal a coating of phosphates which are insoluble in water. A parkerized finish is highly resistant to corrosion. It is not a superficial covering but is formed by the chemical reaction between the metal parts and the bath in which they are immersed. The following parts are parkerized: barrel and receiver, butt plate assembly, bolt, extractor, floor plate, guard and upper band.

The oil black finish is somewhat more smooth than that obtained by the Parker process, but is not as resistant to corrosion. However, it does give sufficient protection to the parts on which it is applied. The parts to be reblacked are dipped in oil, placed in a rotary furnace at 600 to 650° F. and held for approximately one-half hour and then removed and quenched in oil. The following components are oil blacked: hand guard clips, lower band, spring and swivel, rear sight parts, sleeve assembly and stacking swivel.

The firing pin assembly is browned. A parkerized finish would not give the smooth finish which is required for the functioning of this part, and it cannot be oil blacked because the temperature to which it would have to be heated would draw the temper on the cocking piece.

The stocks and handguards which have been accepted

after the necessary machining operations have been performed are scraped, sanded and immersed in raw linseed oil and allowed to remain in the oil about five minutes, after which they are removed and allowed to dry.

COMPONENTS and minor assemblies after being refinished are sent to the component room, from which they are drawn in small lots for the reassembly of the rifle. All minor assemblies are first completed. Before the bolt is assembled the extracting and cocking cams on the bolt, and the sear contact point and the cocking cam of the firing pin assembly are buffed to remove the rough finish from these surfaces. The graduation marks on the rear sight leaf and the movable base are likewise buffed. The part of the receiver against which the bearing of the trigger seats itself is polished to insure smooth bearing surfaces between these working parts. The assembling of the rear-sight fixed base and the front-sight fixed stud to the barrel are considered manufacturing operations and the barrel when received at the assembly shop has these components assembled to it. The minor assemblies being completed are assembled to form the rifle.

Fig. 8. Scraping Gun Stocks at Springfield Armory.

In the rifle assembly the barrel and receiver are first assembled. For this operation a special wrench which fits over the receiver and a pneumatic vise (Fig. 5) are used. The receiver is screwed onto the barrel until the draw line of the receiver is aligned with the draw line on the fixed base. If a new barrel is used it is hand reamed, as shown in Fig. 6, for the correct headspace. A master bolt of minimum gage is used for testing headspace and it must close on a 1.940-inch cartridge and must not close on a 1.946-inch cartridge. The headspace is again gaged when the bolt is assembled to the rifle. Different bolts are tried until satisfactory headspace is obtained. In assembling the sear and trigger to the receiver a test is made for a dangerous trigger pull. This consists of taking up all the warning pull of the trigger and then trying to lift the cocking piece away from the sear, thus permitting the firing pin to go forward. To eliminate dangerous trigger pulls high sears are used with receivers having large well holes. The trigger pull is then weighed and should be between 4 and 5½ pounds. The bolt lift is tested (Fig. 7) and should not be over 15 pounds. When the rear sight assembly and windage screw are assembled to the fixed base a test is made to see that there is no back lash between the windage screw and the movable base. The presence of back lash, which is caused by wear in the engaging parts, is indicated if there is no perceptible movement in the movable base when the windage screw knob is rotated slightly. When all the components have been assembled to the rifle it is ready for the proof and function firing tests.

DUE to the wide variety of service to which the rifle is subjected, it necessarily must have a higher factor of safety than most other classes of ordnance matériel. In testing the rifle to see that it will withstand stresses similar to those developed under abnormal conditions of pressure, due to defective ammunition or other causes, it is fired with two high pressure cartridges which develop a pressure of 75,000 pounds per square inch. The headspace is gaged before the proof and function firing, the limits being 1.946-inch and 1.940-inch. After the first high pressure round is fired the empty cartridge is examined. Defects in the chamber such as ring marks from the reamer will be imprinted on the cartridge. These defects will not generally show on a service cartridge, but after the gun has been fired continuously for any length of time they make extraction difficult. Five service rounds are fired after the first high pressure charge, thus to test all the functioning parts. The second high pressure charge is fired and the empty cartridge is kept with the rifle until the final inspection, when it is examined by a metallurgist. Some defects which do not show up on the cartridge of the first high pressure round are evident when the second cartridge is examined. If the rifle has passed successfully the proof and function firing tests, a punch mark is placed underneath the bolt handle near the body of the bolt. Also a "P" is stamped underneath the stock. These marks indicate that the bolt and also the assembled rifle has been proof and function fired.

The headspace is again gaged to see that there was no setback on any of the parts, which determine the headspace, due to the firing of the high pressure ammunition. A special guard (Fig. 9) is used in the proof and function firing tests.

The function and proof firing also serve the purpose of settling the barrel and receiver in the stock, and this "bedding in" has been found necessary before the next operation, bore sighting, can be done. Every time the action assembly is removed from the stock and replaced, it will have a tendency to "bed in" differently, and for extreme accuracy every time the stock of the rifle is changed the rifle should be bore sighted. The rifles are thoroughly cleaned after the function firing, as the bore

must be smooth and free from all metal fouling before the rifle can be boresighted.

THE following equipment is used in the bore-sighting operation: bore-sight rest, target, bore-sight, front sight limit gage and bore-sight test gage. The bore-sight rest is mounted on a stand which is supported by a rigid foundation. When the rifle is placed on the rest it is secured in place by means of a clamp at the muzzle end and the butt of the rifle is supported at about the center of the lower side of the floor plate. This support is a sliding bearing and prevents the barrel from being sprung when clamped at the muzzle. A vertical and horizontal adjustment is provided at the rear of the bore-sight rest for alignment of the bore of the rifle on the target. The target is at a distance of 75 feet from the muzzle of the rifle when the rifle is on the rest. The bore-sight, which is made of light steel tubing, is provided at the rear end with a sighting hole which is so located as to compensate for the sag of the tube when it is inserted in the bore of the rifle. In the front end of the tube is a set of horizontal and vertical cross wires. A small rectangular block on the fornt end of the bore-sight is brought up against a set of jaws on the clamp and this indicates that the cross wires are in their true horizontal and vertical positions. The bore-sight test gage is for testing the concentricity of the bore-sight test tube.

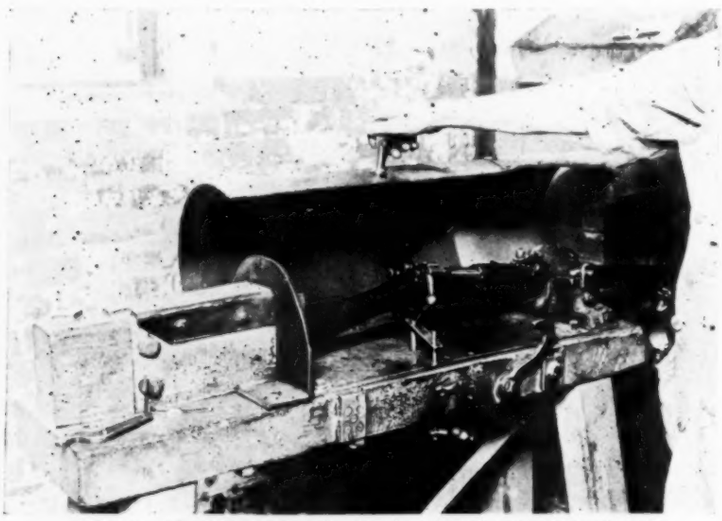


Fig. 9. Proof and Function Firing the Overhauled Rifle at Springfield Armory.

Before boresighting, the index line of the drift slide peep hole is set at 500 yards as this range corresponds to the battle sight range when the leaf is down, and is also the range at which the drift of the rifle is zero. The right-hand side of the wind gage is set at zero and the rifle is clamped in the rest ready to be boresighted. The bore-sight tube is inserted in the muzzle and the cross wires are brought into their proper position in the bore and are then aligned properly with the targets by means of the adjusting device on the rest. With the rear sight leaf raised and looking through the peep hole the sights should be aligned on the target. If they are not the front sight movable stud is adjusted, until they are in line, by means of the front sight adjusting screws which are attached to the muzzle clamp. If the movable stud projects more than .02-inch it is not accepted. A barrel which is bent or sprung due to a warped stock will not bore-sight properly. An index mark is placed on the face of the fixed stud and the movable stud after it has been boresighted. The movable stud is drilled for the front sight screw and the screw is put in place.

AFTER the rifles have been boresighted they are thoroughly cleaned in preparation for the final inspection. This inspection includes making such adjustments as may be necessary to insure the proper functioning of the rifle. All the working parts are tested. A clip of five dummy cartridges is used to test the feed and extracting mechanism. The bore is inspected for bulges, erosion, rust and metal fouling. The stock and bolt are examined for proof marks. In testing for headspace, if the bolt handle can be pushed down with a light pressure of the hand, when a maximum cartridge 1.946-inch is in the chamber, it will be taken as an indication of too much headspace. The trigger pull must be between four and five-and-one-half pounds, and the bolt lift should not be over 15 pounds. A test is made for excessive creep which is a decided backward movement of the trigger after the warning pull and before the sear is released. The action is also tested to see that the sear cannot be released by a forward movement of the trigger. This defect exists when the trigger slot in the guard is too big or out of position, permitting sufficient forward movement of the trigger to cause the sear to release the cocking piece. The rifle, while cocked, is dropped about one foot, allowing the heel of the butt to strike the floor, and if the trigger is released the rifle is not considered safe. The clearance between the reserve lug on the bolt and the shoulder on the receiver should be at least .004-inch. The striker point projection is gaged and should be between the limits .050-inch and .075-inch and the striker hole should not be over .085-inch in diameter. The front sight is gaged for height and should be between 1.064-inch and 1.066-inch above the center line of the bore. There should be no lateral movement of the rear sight movable base with respect to the fixed base when the leaf, while raised, is rocked to the right and left. There must be a slight clearance, about .05-inch between the tang of the receiver and the stock. Stocks without this clearance have been found to crack just in rear of the tang due to the pounding of the receiver against the stock when the piece is fired.

When the rifle is finally accepted it is covered with a rust preventative compound, packed ten rifles to a chest, and the chest is marked "A. O." to indicate that the rifle has been overhauled at an arsenal. The rifles then start on their varied careers again, some to be used and some to be abused. After serving their purposes, being worn out and fatigued, they are again declared unserviceable and are again returned to be overhauled.

The 14th Ordnance Company (Maintenance) At Springfield Armory

By Lieut. Arthur D. Elliot,* Ord. Dept., U. S. A.

THE 14th Ordnance Company is an outgrowth of an Ordnance detachment whose history dates back to the Civil War period. The enlisted strength of the early detachment varied between 33 and 75 men dependent upon the various duties that were thrust upon it. Records of those days disclose that their principal activities were confined to guard, the maintenance of the armory grounds, the handling and storage of armory supplies and the care and supervision of the cows, chickens and gardens that supplied the existing mess with fresh produce. The detachment was quartered in a commodious three-story brick building which had been built in 1808 and then known as the West Arsenal. This building, having been modernized, is in excellent condition and is now used as the barracks of the existing garrison.

In compliance with Circular 23, War Department 1921, the 14th Ordnance Company was organized on February 10, 1921, from the personnel of what was known as the Armory Detachment of Ordnance then on duty at Springfield Armory.

As organized, the Company consisted of one officer and 48 men but since that time the authorized peace strength has been reduced to one officer and 37 men. It was intended that this company be specilized in the maintenance of small arms and machine guns with a view towards making it a training center for specialists for the repair of small arms and machine gun matériel in addition to the basic military training. As time went on, owing to the demands upon the reduced personnel to perform the usual Armory duties, it was necessary to dispense with the proposed specialists instruction. Advantage is now being taken by two or three men annually from this organization of the comprehensive courses given at the Ordnance Specialists School at Raritan Arsenal. A three months' course of intensive training in the field repair, maintenance and overhaul of small arms, the automatic rifle, machine gun and the 37-mm. gun is given yearly in the shops of Springfield Armory to specially selected men of the organization. This course is under the supervision of an officer assisted by civilians who are experts in their particular class of work and includes in addition to the above, instruction in the methods of preserving and packing small arms for storage. A short course is given in those portions of the Field Service and Training Regulations which pertain to the duties of a maintenance company.

DURING the past four years a detachment of twelve enlisted men for this organization in charge of an officer on duty at the Armory has been ordered to Plattsburg Barracks, N. Y., for duty at that post during the summer training period of the R. O. T. C. and C. M. T. C. camps. While there, a complete inspection and field repairs of the small arms and machine gun equipment of the 26th Infantry are made by the personnel of the detachment and a report made to the Corps Area Ordnance Officer of the general condition of Ordnance matériel. As the training season progresses the detachment maintains and repairs the rifles of the R. O. T. C. and C. M. T. C. students and at the end of these camps all rifles are thoroughly overhauled, prepared and packed for storage. The detachment travels over the road to Plattsburg, a distance of approximately 215 miles, with a small arms repair truck, two 3-ton cargo trucks and one Dodge light repair truck. This equipment has been found to be amply sufficient to perform the duties at the summer camp. The experience gained in road travel and in the maintenance work is invaluable to the personnel of the detachment and as changes are made in the personnel annually the organization as a whole is particularly qualified in the care and repair of small arms matériel.

During the winter months the trucks and equipment used during the summer camp are thoroughly overhauled by the automotive section. Further instruction is given to the entire personnel of the organization in the maintenance of the caliber .30 Browning machine gun and automatic rifle, the Springfield rifle, M 1903, and the caliber .45 automatic pistol preparatory to the intensive instruction previously described. Basic military training is given throughout the year and the general tone and esprit of the organization is increasing.

The Old West Arsenal, Built in 1808, Now Used as Barracks for the 14th Ordnance Company (Maintenance) at Springfield Armory.

*Commanding Officer, 14th Ordnance Company, Springfield Armory, Springfield, Mass.

Tracer Ammunition

Part III: Proof Testing

By Capt. S. P. Meek,* Ord. Dept., U. S A.

THE proof tests made on tracer ammunition may be divided into four separate groups, viz.: tests made on the tracer mixture and igniter prior to loading the bullets, daily firing tests on the bullets as they are loaded prior to their assembly into complete rounds, acceptance tests made on the completed ammunition prior to turning it into store for issuance to the using services, and surveillance tests made on ammunition that has been accepted and issued for use. Each group has its own distinctive program of tests that are not alike, each program being designed to obtain the information essential at the time the tests are made.

As mentioned in Part I of this paper (Army Ordnance, March-April, 1928), tracer mixture and igniter are made up in lots sufficient to load 200,000 rounds of caliber .30 ammunition. The mixture and igniter are each made up in small lots for the purpose of convenience in manufacture and to avoid danger, and these small units are blended into lots of the size mentioned above. When a lot has been completed, a sample is sent to the inspection department for test. The tests on the mixture are the sieving test, the homogeneity test, the loading test, the static burn test and the firing test. These will be described in order in the following paragraphs.

Lighting Caliber .30 Tracer Bullets for Static Burning Test.

The sieving test consists of sieving the sample through commercial screen by hand. The homogeneity test consists of a visual examination to detect streaks or other evidences of heterogeneity. In case the material fails on this test it is reblended until it is uniform. After the material has passed the tests described above, it is sent to the loading room for the loading or manufacturing test. There 500 bullets are charged with the mixture using an already accepted igniter lot. No difficulty must be experienced in the loading and the amount of manufacturing scrap must not be excessive.

The bullets loaded in the manufacturing test are divided into two groups. The first group, consisting of 50 rounds, is sent to the laboratory for the static burn test. These bullets are not based. In this test the bullets are clamped in a fixture, a little loose igniter placed on the bases and the bullets are ignited either with a hot iron rod or a gas flame. The number of rounds that burn normally and the number of seconds that each round burns are recorded. The percentage required to burn normally and the average number of seconds that the bullets are required to burn vary for different mixtures.

Two hundred bullets from the loading test are based and assembled into complete rounds and sent to the proof house where they are fired for functioning only. The functioning firing is done in a Browning water-cooled machine gun. The rounds are fired singly and the functioning of each round recorded. The various types of malfunctions with the cause for each will be explained later.

The tests on igniter lots are similar to the tests on tracer mixture lots with the exception that the sieving test is omitted and that in making the static burn test no time of burning is recorded.

The results of the entire series of tests are reported to the Engineering Section which assembles all data and prepares an acceptance or rejection report on the lot. In case a lot fails, a retest of double the size is authorized. When the mixture has been accepted the mixing shop is informed of the fact and the lot is considered as available for issue to the loading room as needed. It may be mentioned that a tracer mixture lot and an igniter lot are used for the loading of an ammunition lot of tracer ammunition and that any small amounts of the mixture or igniter lots left over are either destroyed or used up on experimental loading. When ready to start loading the tracer loading shop requisitions accepted mixture and igniter from the mixing shop and loads the ammunition as described in Part I.

Prior to any proof tests on the loaded bullets, they get three separate inspections. The first inspection is given by the bullet ejector at the press and is merely for the purpose of checking the size of scoops used and to throw out any bullet that is radically wrong. If there is the slightest doubt of its acceptability it is left in the lot. The lots are

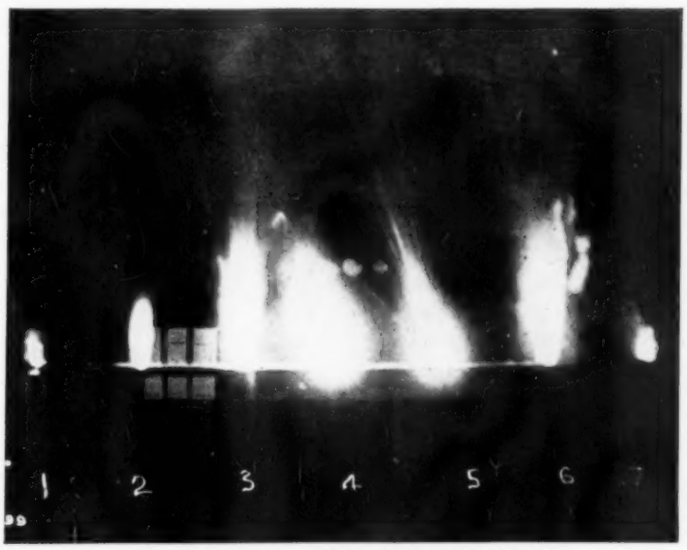
*Formerly in charge of Tracer Ammunition Development, Frankford Arsenal, Philadelphia, Pa.

next inspected by a member of the inspection department who segregates and discards any bullets that are "highs" or "lows" and any bullets that show spilt metal on the base. After this inspection the entire lot is based and again inspected and 1 per cent. taken for what is known as the daily bullet test.

The daily bullet test consists of loading the 1 per cent. of bullets selected at random from the lot into complete rounds and firing them at the proof house for functioning only. In case the bullet lot gives satisfactory functioning, it is released to the loading room and there assembled into complete rounds of tracer ammunition. The completed rounds are given the usual gaging and visual inspection and are boxed. Before packing them the inspection department takes from the lot a representative sample for the final acceptance test on the lot.

THE final acceptance tests are: (1) trace; (2) pressure; (3) velocity; (4) waterproofing; (5) functioning; (6) hangfire; (7) accuracy.

The trace test is fired in a water-cooled Browning machine gun in a similar manner to that described under tests of tracer mixture lots. The pressure and velocity are taken in the customary manner, the pressure being recorded on a copper compression cylinder and the velocity on a Boulongè chronograph. The waterproofing test is the customary one given all caliber .30 ammunition and consists of emersing one-half of a lot under a 12-inch head of water for 24 hours, wiping the cartridges dry and allowing them to come to room temperature and then firing wet and dry shots alternately in the same velocity rifle. The functioning test is fired in a machine gun. In actual practice no separate test is fired but the data required for the functioning test is obtained from the firing of the trace test. The hangfire test is fired in a machine gun and differs in no particular from the hangfire test given to ball ammunition. The accuracy test is fired in a Springfield rifle held in a Frankford Arsenal machine rest. The accuracy of tracer ammunition is inferior to ball, but like all ammunition has undergone great improvement in recent years and today accuracy is often obtained with tracer ammunition that would not have been considered discreditable with ball ammunition a few years ago.



Caliber .30 Tracer Bullets Burning Statically.

1. Model 1917; 2. Model 1923 (Aircraft); 3. Model 1924, green; 4. Model 1924, red; 5. Experimental long range, red; 6. Experimental long range, green; 7. Model 1917.

In firing the trace test there are six distinct types of functioning encountered, viz.: (1) full trace; (2) short trace; (3) partial blind; (4) total blind; (5) muzzle burst; (6) eccentric. A full trace is a round in which the bullet behaves normally. The igniter takes fire and properly relays the flame to the tracing mixture. The mixture takes fire and burns with a visible trace for the full length of the range. In the case of a caliber .30 tracer, this distance is 600 yards. A short trace is one in which the tracing mixture takes fire in apparently a normal manner and traces with a visible flame but the flame goes out less than 600 yards from the muzzle of the gun. Certain slow-burning mixtures are prone to give short traces but aside from a mixture which has this undesirable characteristic, the probable cause of a short trace is discontinuity of the column of tracing material. This may be caused by improper basing, or by a number of other things. This, fortunately, is a type of malfunction seldom encountered in large numbers and consequently little study has been given to it. A partial blind is a round in which the igniter takes fire normally but fails to relay the flame to the tracer mixture. This is a quite common malfunction and is caused by several things. One cause is too weak an igniter. The remedy in this case is to change the igniter. Another cause is too fast an igniter, the remedy in this case being to use a sub-igniter system of loading. Another cause is a separation between the igniter and mixture caused by faulty basing or some similar mechanical trouble. The remedy in this case is obvious.

A total blind is a round that is blind from the muzzle, i. e., the igniter fails to take fire from the hot gases resulting from the discharge of the propellant charge. If this trouble becomes aggravated, the only remedy is to change either the igniter or the propellant charge. The small number encountered in production loading ordinarily is not enough to cause serious trouble.

A muzzle burst is a round which blows to pieces with a sharp report a short distance in front of the gun. Firings made through sheets of cardboard placed some distance in front of the gun muzzle seem to indicate that there are several types of bursts. As the bullets that have burst cannot be recovered for study, the exact cause of a burst is not definitely known, although it is suspected that it is often due to defective metal in the bullet. The remedy, of course, is to secure better metal, or, in aggravated cases, to make a change in bullet design or method of loading.

An eccentric is a round where the tracer mixture and igniter ignite normally but the tracing bullet, instead of following a normal trajectory goes off at an eccentric angle. I have seen eccentrics go in weird curves and spirals and have seen them loop in the air and come to rest in the vicinity of the gun. Eccentrics may be caused by either one of two things, viz., too hot a mixture, or split metal on the base of the bullet. The remedy in each case is obvious. In the first case either change or modify the mixture and in the second case insist on a more rigorous inspection of the bases of the bullets before the basing operation to de-

tect and remove any defective bullets. It may be mentioned in passing that where the cause is too hot a mixture, from 30 to 75 per cent. of eccentrics will be encountered, while if the cause is defective metal, not over 1 per cent. may ordinarily be expected.

There is one other type of malfunction, known as a "floater," worthy of mention. This is a type not ordinarily met with in caliber .30 tracer bullets, but is not infrequent in caliber .50 tracers. A floater is a round in which the bullet, instead of following a normal trajectory, falls or "floats" slowly to the ground some distance short of the full limit of normal trace. Considerable study has been given to this peculiar phenomenon and its cause in a number of specific instances definitely determined. Frequently it is caused by a worn barrel, or too large a barrel. A number of theories have been advanced to account for other instances but at the present time the cause is not well enough known to make a definite statement.

When a lot of completed tracer ammunition is turned into stores for shipment to the using services, one case is retained at the Frankford Arsenal for surveillance tests. Annually, commencing one year from the date of acceptance, a sample of this case is withdrawn and tested. The tests given it are: (1) trace; (2) pressure; (3) velocity; (4) hangfire. Each of the tests is conducted in the manner described for final acceptance tests.

THERE are in addition to the above several miscellaneous tests that should be noted. These are the length of trace test, the uniformity of loading test and the grouping test. The length of trace is determined in two ways. Under the head of static burnings of acceptance lots of tracer mixture the fact was mentioned that the average time of burn was recorded. There is a very definite relation between the time of static burn and the length of trace. By plotting on Cartesian coördinates, using the time of trace in seconds as ordinates and the length of trace in yards as abscissae, a curve is obtained of the general form.

$$Y = pX^2 - p'X + k$$

where p and p′ are factors obtained empirically and k is a constant representing the time interval between the flash of the loose igniter and the ignition of the bullet. By reference to such a curve the average length of trace of a lot of bullets can be predicted with surprising accuracy. Such a curve is of course applicable only to a given velocity of bullets and when the range of grouping is changed with a consequent change in velocity, it becomes necessary to obtain the data to plot a curve for the new velocity. This is done at the Aberdeen Proving Ground on the water impact range. Two observers are stationed in towers approximately forty feet above the water and the location of the gun is so adjusted that the bullets will cease to trace at some point between the two towers which are located one hundred yards apart. The observers in each tower estimate the point at which the bullet ceases to trace and the average of the two estimates is taken as the true figure. With trained observers very accurate determinations of the length of trace may be made.

The test mentioned on the uniformity and density of loading is made only on experimental bullets or when trouble is encountered in production loading. In making the test a loaded bullet is sectionalized or sawed in half lengthwise and the cut surface carefully smoothed off. The sectionalized bullet is examined under a 75 power microscope to detect any cracks or other evidence of discontinuity of tracer column. The bullet is then placed under a standard Rockwell hardness tester and the Rockwell number obtained at various points on the tracer column. The data thus obtained often afford very interesting information not only on the actual pressures being used, but also on the uniformity of the pressure and the packing qualities of the tracer mixture under consideration.

The last test which I will describe is what may be called the grouping test. This is not properly a test at all, but is a routine manner of establishing the correct charge for the loading room. This is fired in a Mann barrel held in a Mann "V" block secured to a machine rest. A ten-shot target of ball ammunition is fired and caught on a screen at the range at which it is desired to group the two types of ammunition. The center of impact of the ball ammunition group is then located. Tracer bullets are hand-loaded into cases with different charges of powder and fired through the same barrel with the same setting and the point of strike observed. The powder charge of the tracer ammunition is adjusted until the center of impact of the tracer ammunition coincides with the center of impact of the ball ammunition. In taking the center of impact of the tracer ammunition any blinds encountered are not considered as it has been found that a blind will strike the target at a point considerably below the point of strike of a tracing round.

(This concludes the series of articles on Tracer Ammunition by Captain Meek.)

SUPERINTENDENTS AND COMMANDING OFFICERS, SPRINGFIELD ARMORY, 1794-1928

Names of Superintendents and Commanding Officers	Date of Assumming Charge or Command	Date of Relinquishing Charge or Command
David Ames, Supt.,	1794	Oct. 31, 1802
Capt. Joseph Morgan Supt.,	Nov. 1, 1802	Oct. 31, 1805
Benjamin Prescott, Supt.,	Nov. 1, 1805	Aug. 31, 1813
Henry Lechler, Supt.,	Sept. 1, 1813	Jan. 15, 1815
Benjamin Prescott, Supt.,	Jan. 16, 1815	May 31, 1815
Lt. Col. Roswell Lee, Supt.,	June 1, 1815	Aug 25, 1833
Lt. Col. Geo. Talcott, Ord. Dept.	Aug. 26, 1833	Oct. 31, 1833
John Robb, Supt.,	Nov. 1, 1833	Apr. 15, 1841
Maj. J. W. Ripley, Ord. Dept.	Apr. 16, 1841	Aug. 16, 1854
Gen. James S. Whitney, Supt.,	Oct. 19, 1854	Mar. 1, 1860
Col. T. H. Wright, Supt.,	June 27, 1860	Apr. 25, 1861
Capt. Alex. B. Dyer, Ord. Dept.,	Aug. 25, 1861	Oct. 27, 1864
Maj. T. T. S. Laidley, Ord. Dept.,	Oct. 27, 1864	May 14, 1866
Maj. T. G. Benton, Ord. Dept.,	June 14, 1866	Aug 23, 1881
Lt. Col. A. R. Buffington, O. D.,	Oct. 3, 1881	Feb. 2, 1892
Col. Alfred Mordecai, O. D.,	Feb. 2, 1892	Feb. 21, 1898
Lt. Col. Isaac Arnold, Jr., O. D.,	Feb. 21, 1898	May 29, 1899
Lt. Col. F. H. Phipps, O. D.,	June 5, 1899	Aug. 9, 1907
Col. S. E Blunt, Ord. Dept.,	Aug. 9, 1907	Sept 1, 1912
Lt. Col. W. S. Peirce, Ord. Dept.,	Sept. 1, 1912	Jan. 10, 1918
Lt. Col. G. H. Stewart, Ord. Dept.,	Jan. 10, 1918	Mar. 15, 1918
Col. Jay E. Hoffer, Ord. Dept.,	Mar. 15, 1918	Sept. 16, 1918
Lt. Col. L. D. Hubbell, Ord. Dept.,	Sept. 16, 1918	Apr. 14, 1920
Col. Thales L. Ames, Ord. Dept.,	Apr. 15, 1920	Aug. 7, 1923
Maj. Earl McFarland, O. D.,	Aug. 7, 1923	June 15, 1924
Col. H. W. Schull, Ord. Dept.,	June 18, 1924	.....

The Tenth Annual Meeting

OF THE

ARMY ORDNANCE ASSOCIATION

WILL BE HELD AT

The Aberdeen Proving Ground, Maryland

THURSDAY, OCTOBER 4, 1928

The following organizations will participate:

American Society of Mechanical Engineers

American Institute of Electrical Engineers

The Association of Military Surgeons of the United States

The Construction Division Association

The program of demonstrations will include scientific and tactical exhibitions of Army equipment.

Further announcement as to the program of events, special trains, reduced railroad rates, and meals will be published in the September-October issue of ARMY ORDNANCE.

Members of the Army Ordnance Association and of the participating organizations will receive personal invitations and complete details in due course. This will be the Tenth Birthday Party of the A. O. A. so reserve this date: Thursday, October 4, 1928.

Editorial

Springfield Armory

"This is the Arsenal. From floor to ceiling,
Like a huge organ, rise the burnished arms;
But from their silent pipes no anthem pealing
Startles the villages with strange alarms.
—Henry Wadsworth Longfellow.

THUS the poet begins his elegy, "The Arsenal at Springfield," written many years ago. The "burnished arms" still rise at that venerable establishment, today, thank Heaven for it, as at the time the verses were struck off, "their silent pipes no anthem pealing." Shades of Thomas Blanchard, Eli Whitney and Simeon North, pioneers of the New England gun makers, still hover in the old precincts. Samuel Colt, inventor of the revolver; Christian Sharpe and Capt. John H. Hall with their breechloading rifles; Christopher Spencer and his repeating rifle; Elisha Root of drop hammer fame, have come and gone leaving their imprint on the record of American small arms development and manufacture, and Springfield Armory whose birth coincided with the very beginning of our Federal Government, whose products for a century have been known the world over, the skill of whose artisans is synonymous with perfection in interchangeable manufacture, Springfield still carries on.

This present issue of ARMY ORDNANCE is a Springfield Armory number. Through the courteous coöperation of Col. H. W. Schull, Ord. Dept., U. S. A., Commanding Officer of Springfield, and the members of his military and civilian staffs, articles descriptive of the Armory and its activities are presented. It is hoped that these discussions, presenting as they do an authentic and current account of our premier small arms establishment, will prove of interest to readers generally and will constitute a permanent record in the annals of this all-important subject.

It may not be amiss at this time to emphasize one of the important roles Springfield Armory has in our national defense plans. In addition to the function of supplying new weapons and repairing old ones for a large contingent of our military and naval forces, Springfield conducts an experimental laboratory the importance of which equals, if it does not transcend, that of the manufacture and repair functions. This experimental function, in our opinion, is what it is principally because of the brakes it can put on tomfoolery rather than the acceleration it can give to novelty. In all respects, save possibly the development of a satisfactory semiautomatic rifle, our American forces are armed with superior weapons. But the admission—always tacitly concurred in by the rank and file—might just as well be made publicly: there are more cranks who have gone daft on small arms than in any other field of munitionment.

There is the great confraternity of enthusiasts who demand the absurd niceties on their guns. For finickiness they leave in the shade those proponents of the ancient and honorable game of golf who require so many clubs of finely balanced grades of weight, loft and feel that one caddy bag can scarcely hold them. And these range in the other extreme even to those who demand ranges and rates of fire that are never—well hardly ever—required in actual battle. And between these extremes are every kind and variety of opinion. Praiseworthy as are its investigations of errosion and corrosion, its development of a semiautomatic rifle, its varied experiments toward improvement of one element or another, we incline to the belief that sanity of judgment is the prime function of such an organization and is far and away its most exacting duty.

Springfield Armory in this and other related aspects today holds high place. It acts in close coöperation with commercial arms and ammunition companies. Its roster of military personnel contains, as in the past, the names of officers who are renowned for their knowledge of the art. It possesses a corps of civilian employees whose life work and that of their fathers before them is exemplified in the character of workmanship that is one of Springfield's glories.

Guardian of our peace and homeland may Springfield, old but ever young, continue with added glory her century and a half of service—adding as it does to the assurance that war will remain all the more remote and we shall continue to have

"Peace! and no longer from its brazen portals
The blast of war's great organ shakes the skies
And beautiful as songs of the immortals
The holy melodies of love arise."

Other Things the Army Did Besides Fight

WE are indebted to our contemporary *The Coast Artillery Journal* for unearthing an elaborately tied bow of Army red tape of thirty years ago. Here it is, follow closely:

On January 23, 1895, the acting Quartermaster at Davids Island, New York Harbor, addressed a memorandum to the Chief, Commissary of Subsistence at New York, requesting authority for the purchase of "8 sheets of zinc at $1.10 per sheet—$8.80, and 4 pounds, 1 inch galvanized nails at 4 cents per pound to line a bin which is under construction for the purpose of securing the bacon which is kept on hand for issue to troops at this station. The cellar is so damp that it is an impossibility to keep the meat from moulding if not kept in salt." This humble request for an insignificant but necessary sum proceeded upon the following labyrinthic journey. First to the Commandant at Davids Island who forwarded it to the Chief Commissary of Supply who forwarded it to Assistant Adjutant General, Department of the East, inviting attention to Army Regulations 1347, who returned it to the Commanding Officer,

Davids Island for compliance, who forwarded it to the Post Assistant Commissary of Supply, who returned it to the Commanding Officer requesting that the Post Adjutant be directed to make formal requisition in accordance with the Army Regulation cited, who forwarded it to the Post Quartermaster to make the requisition.

Thereupon the Post Quartermaster transcribed the original request on the necessary form and forwarded it to the Commanding Officer of the Post who again forwarded it to the Assistant Adjutant General, Department of the East, who forwarded it to the Chief Quartermaster, Department of the East, who returned it to the Assistant Adjutant General, Department of the East, "recommending that the requisition be forwarded with recommendation that purchase of the zinc and nails called for be authorized, cost not to exceed $8.96." Then in 12th indorsement signed by Maj. Gen. Nelson A. Miles, Commanding, Department of the East, the lowly requisition, now accompanied by voluminous correspondence, was forwarded to the Adjutant General of the Army in Washington and transmitted by him to the Quartermaster General of the Army. Here the request was vetoed, "The sheet zinc would quickly rust out when covered with salt brine, and the oxide of zinc that would form would poison the brine." Bingo!

Back went the fiat over the circuitous route by which it had arrived and finally lodged at the point of origin. But this die-hard tried again and replied "The zinc called for is not intended to line the inside of the bin for the bacon, but to line its outside to prevent rats entering it." Once more, with this additional evidence and by 19th indorsement, the request for the expenditure of $8.96 travelled the same path and again ended up in Washington where by 22nd indorsement on February 26, 1895—one month and three days after the start—the Office of the Quartermaster General respectfully returned it "with information that the previous action of this office disapproving this expenditure is adhered to."

What little need there is for comment may be alleviated by the fact that, after a fashion, business finally got into government and the Gordian knot of red tape was somewhat unravelled. Passing years brought other changes and with the World War came a general reform. Thanks to the boon of present day efficiency, modern methods now prevail. And it is hoped that the War Department Business Council—that group of first rate business men advisory to the Assistant Secretary of War—will keep a watchful eye on just such apparently trivial methods which if left to grow and become custom gradually may again revive such asinine procedure as determined the fate of the piece of zinc and the nails.

Our Tenth Birthday

AS announced elsewhere in this issue, the Army Ordnance Association will celebrate its tenth birthday—the flourishing little fellow having celebrated its first the day he was born—on Thursday, October 4, 1928, at the Tenth Annual Meeting of the Association at the Aberdeen Proving Ground, Maryland.

The American Society of Mechanical Engineers having been on hand in the first instance will return to help do the shouting at the tenth. In addition, the American Institute of Electrical Engineers, the Society of Military Surgeons of the United States, and the Construction Division Association also will participate.

Plans are progressing for the greatest demonstration of fighting equipment ever held at Aberdeen. Considering the nature of past meetings that means a lot. Members of the Army Ordnance Association and of the participating organizations will receive personal invitations and other data in due course. It is hoped that all members will be on hand to witness this great educational demonstration which will start the A. O. A. on what is hoped will be an even greater period of usefulness than the past.

It has been remarked on innumerable occasions as well as in these pages that the annual meeting of the Association has become an institution of tremendous educational value. This is as it should be. The Secretary of War and Chiefs of all branches of the Army are most gracious in their cooperation. This year the number of exhibits will probably exceed those of any previous meeting. It is our firm belief that the purpose of these exhibitions is one of the most unique developments of post-war national defense thought. It is hoped that the increasing attendance is a positive indication of the value of the theory that the folks who will have to design, build and maintain the ordnance of the future should see what modern munitions are "in the flesh" so that they will not be utter strangers should they ever again meet when time can not be taken out for lengthy introductions.

The National Matches

DUE primarily to the persistent efforts of the National Rifle Association, the National Rifle Matches are being held again this year. Camp Perry, Ohio, will be the field of battle with indications pointing to an elaborate scene, the actors in which will be the riflemen of America—the good and the bad, the expert and the amateur.

The National Matches are an unique institution offering the only nation-wide forum where shooters from Maine to California meet upon common ground and fight it out. The spirit of competition aroused by this modern joust has in it all the elements of chivalrous rivalry of the days when knighthood was in flower, lacking only the gaudy trappings. The tunic, the hauberk and the bow give place to the peep-sight, the boat-tail bullet and the rifle.

That this matching of skill and its consequent rivalry mean much to the general advancement of interest in rifle shooting is a truism. That the portion of the cost of conducting the Matches borne by the Federal Government, if kept within reason, is money well spent is, in our opinion, equally patent. Modern life contains all too many incentives to forsake the gun for other more convenient avocations. Sports in general are claiming more and more followers but when one's interest is that of being among the 70,000 who look on while 18 or 20 highly paid athletes go through nine innings of a ball game the ratio is not so imposing from the real sports viewpoint.

Therefore that field which in addition to its sports aspect has the potency of rearing expert defenders of the land might be said to be the most worthwhile of them all. Rifle shooting is that and should be fostered with all reasonable assistance.

The Army Ordnance Association again this year will present a trophy to the winner of the President's Match at Camp Perry. The award will be a special U. S. Rifle, Caliber .22, Model 1922 M1. Here's hoping that the best man wins and that winners and losers alike will profit.

Professional

Radium Atomite—A New Explosive

IN response to a request from the Editor for information concerning a new explosive recently announced in the daily press, Capt. H. R. Zimmer of Los Angeles, Calif., has very graciously forwarded the following information:

"I have been carrying on experiments with radium for the past twenty-five years and during that time have been hopeful of finally producing a high explosive, without the present hazard of manufacturing and handling.

"What I have named radium atomite is the result of these experiments. This new explosive has been tested to some extent in the past month with pleasing results, but I believe these results will be bettered in many ways in the near future.

"The explosive is made from a vegetable carbon base, contains no nitroglycerin, cellulose, or gun cotton.

"Speed tests up to the present time show a speed of 10,722 feet per second. I believe this can be stepped up to possibly 20,000 feet per second. As the tests have shown, it can be made in any speed desired and has been used very successfully as a propellant powder in the Springfield rifle, showing a greater penetration through pine boards than the present Government loads.

"It produces very little heat in its combustion and the projectiles were perfect in shape. The holes in the wood were perfectly straight and round. The recoil is much less than one-half and the report less than one-half that of the Government powder.

"The expansion tests carried on at the California Institute of Technology under the direction of Col. L. M. Adams, were made with lead cylinders 12 inches in diameter and 14 inches in height, weighing 696—696½ and 700 pounds, respectively. When the lead cylinders were sawed into, it was found this difference in weight was due to air holes in the cylinders. The hole in these cylinders before shooting was one inch in diameter, and nine inches deep. The cylinder weighing 696 pounds was loaded with one ounce of 80 per cent. gelatine; the cylinder weighing 696½ was loaded with one ounce of TNT; the cylinder weighing 700 pounds was loaded with one ounce of radium atomite.

"Before shooting these holes showed a capacity of 125-cc. of water. After shooting the cylinder in which 80 per cent. gelatine was used measured 1360-cc. The cylinder in which TNT was used measured 1060-cc. The cylinder in which radium atomite was used measured 1700-cc. Showing that TNT executed 60 per cent. the strength of radium atomite, that 80 per cent. gelatine was 78.5 per cent. of radium atomite.

"Analysis of the explosives by Smith-Emery Company of Los Angeles shows the ignition point to be 148°C. Freezing impossible. No hydroeyanic acid or cyanides. Carbon monoxide 21 per cent., which is the only poisonous gas.

"This explosive has been used in underground mine drifts firing eleven holes to the round in hard rock, with positively no ill results to those entering the drift immediately after the last shot was fired. There are none of the usual ill effects, such as headaches from handling, or breathing the fumes.

"This explosive can be manufactured completely from the raw materials in eight hours elapsed time.

"There is no danger of exploding while being manufactured and at no time until it is a finished product can it be burned. It cannot be exploded by hammering, friction, or a jar and has shown under actual working conditions, to produce ten times the working efficiency of 60 per cent. dynamite."

"New Methods in Exterior Ballistics"

IN the March-April, 1928 (Vol. VIII, No. 47), issue of this Journal, Colonel Moulton replies to my comments of a year previous on his above-entitled book. May I have the space to clear up some misconceptions which are doubtless due to my not having been sufficiently explicit?

First, as to his book not employing the official notation. This, of itself, is relatively unimportant, except as to the annoyance which it may cause those using the book in connection with official Army work. The point was cited chiefly as evidence that Colonel Moulton was not in touch with post-war developments, this evidence being merely cumulative with his evident unawareness of the new coördinate system and the work of Kent, Ritt, Gronwall and Franklin.

Secondly, with regard to the Bliss system of differential variations. In his reply, Colonel Moulton repeats the assertion of his book as to the limited applicability of the Bliss system, and cites Bliss as agreeing with him. This indicates that Bliss "builded better than he knew." If Colonel Moulton will familiarize himself with Franklin's derivation of the Bliss system, I feel sure that he will agree that Franklin has demonstrated the universal applicability of that system. In fact, many other misapprehensions, current in other quarters, as to the exact meaning and use of the Bliss system, would be completely dissipated by a proper realization of the Franklin derivation and its intendments.

Thirdly, with regard to Colonel Moulton using the Siacci-Ingalls tangent plane as his datum, instead of using the curved surface of the earth. As pointed out in ARMY ORDNANCE, May-June, 1928, all the computations are done in a rectangular cartesian system, regardless which datum is used. The only practical difference between the two data lies in the method of applying the results to the actual curved earth. Thus for Colonel Moulton to apply his results according to the modern convention would in no way involve sacrificing any of his mathematics.

Finally, Colonel Moulton appears to misinterpret the spirit in which the review of his book was written. As I stated in that review, "I yield to no one in my respect,

admiration and gratitude for the contribution which Professor Moulton made to the science of gunnery when, as a Major of Ordnance in 1918, he reverted to first principles and laid the foundation for a new Ballistics adequate to deal with the problems of modern matériel." And again: "his book is an invaluable addition to the history of mathematical physics." An autographed copy of his book is among my treasured possessions. Colonel Moulton possesses, in my estimation, the ablest mind which has tackled ballistic problems in a generation.

And so my review was inspired by a deep and genuine regret that the man best capable of understanding, appreciating, justifying and extending the advances which have been made in ballistics since 1918, should not have been kept in touch with these developments. If the present discussion results in focusing the attention of Colonel Moulton on ballistics as it is today, the science cannot but be the gainer.

ROGER SHERMAN HOAR,
Major, Ord. Res., U. S. A.

Development of U. S. Rifle Caliber .22, Model 1922

FOR preliminary target practice before the World War the service used caliber .22 short ammunition fired from a regulation Springfield rifle using a caliber .22 barrel chambered to the dimensions of the standard caliber .30 cartridge case. The cartridges for this rifle were held in steel holders of the same general shape as the caliber .30 cartridge. It was practically impossible to obtain accuracy with this weapon and the system was abandoned during the war, although as early as 1915 experiments were in progress to eliminate the objectionable features of this rifle. The Army adopted a plan in 1919 of reloading caliber .30 ammunition for firing at reduced ranges, using a reduced powder charge and a 140 grain lead bullet. This practice proved very unsatisfactory and was later abandoned.

The experimental design of a new caliber .22 rifle which commenced in 1915 progressed at odd times until the early part of 1917 when work on this project was discontinued. Consideration was again given to the design of this rifle in 1919 when Mr. Coon, an employee at Springfield Armory, submitted a design of a bolt action caliber .22 gallery practice rifle using a long rifle cartridge and of the same general appearance as the caliber .30 rifle, Model 1903.

The cartridge holder used in the earlier type of rifle was eliminated and the cartridges were fed directly into the chamber of the rifle from a small magazine placed inside of the regular magazine. It was thought that the use of the long rifle cartridge would increase the accuracy and functioning of the rifle. Authority was granted to construct and test two rifles of this design. One rifle of the same weight, balance, length of stock and bolt operation as the caliber .30, Model 1903, rifle, designed by Mr. Coon and with ballistic specifications suggested by Mr. A. L. Woodworth, was completed and tested early in 1920.

The barrel was rifled with four grooves of uniform right hand twist, one turn in 16 inches, the bore diameter being .2175-inch and depth of groove .003-inch. Both accuracy and range were increased due principally to the use of the long rifle cartridge. To test the accuracy, long rifle ammunition, manufactured by several commercial firms, was used. A mean radius of one inch was obtained from a group of ten targets of ten rounds each firing from a machine rest at 100-yard range. At 200 yards the mean radius increased to 3.05 inches. This performance was greatly superior to that of the earlier type of rifle. The results were such that the rifle was thought sufficiently accurate for military target use up to 200 yards and could be used in the National Rifle Matches at Camp Perry.

Some of the mechanical features of the rifle were noticeably good, principally the bolt action, a double striker insuring complete and instantaneous ignition and the box magazine which was easily inserted through the floor plate and loaded cartridges directly into the chamber by the cam action of the bolt. The receiver was cut away in such manner as to make the chamber accessible for loading single shots and readily to permit cleaning of the bore from the breech. The rifle having a small number of machined parts was easy to manufacture and could readily be assembled and disassembled.

THE success of the preliminary observations and test of this model of rifle warranted the expenditure of funds to produce a small quantity for further development and subsequent modifications. During the test certain observations indicated that it would be necessary to produce a barrel that would fire all makes of ammunition accurately due to the variation in ammunition manufacture. In order to overcome this difficulty, it was found that the width of the lands had to be reduced and the grooves correspondingly increased. Due to the construction of the cutters then in use, the grooves were narrow and the lands very wide, causing the larger bullet of certain commercial ammunition to upset in flight resulting in a wild shot. In view of the fact that the accuracy tests had been conducted in a barrel with four grooves and a rifle was being commercially manufactured with six grooves it was decided to conduct further experiments to determine the advisability of definitely adopting a barrel with four or six grooves. After numerous experiments with barrels of four and six grooves of many different dimensions and using three different types of commercial long rifle ammunition at 100-yard range in a machine rest, a four groove barrel having a minimum diameter of .2175-inch, maximum of .2180-inch, and a groove minimum diameter of .2225-inch and a maximum groove diameter of .2230-inch was adopted.

Having settled finally on the barrel dimensions, concentrated effort was centered on other refinements. The pistol grip stock was adopted, the lower band placed one and one-half inches nearer the butt in order that the distance from the butt plate to the sling swivel would be approximately the same as that of the service rifle, the butt plate manufactured from steel and checkered and the balance of the rifle changed and the weight reduced by certain modifications in the stock. The Lyman sight was changed by transferring the windage scale to the front side of the bridge and omitting the hinged peep and the addition of the disc for target work. The firing pin assembly was also changed to secure a quicker action of the pin and striker.

FURTHER developments extending over a period of two years were made in an endeavor to improve the accuracy of the rifle. Positive and uniform ignition with all makes of commercial ammunition was obtained by the modification of the striker from the earlier double striker point type to a one-piece striker, the point of impact of which was just within the periphery of the base of the cartridge case.

This change also reduced manufacturing cost and facilitated production. To insure the seating of the bullet centrally within the rifling and to overcome objectional gas leakage the inside diameter of the chamber was modified materially. A new magazine was designed whose cartridge capacity equalled that of the earlier type and the bottom of which seated flush with the floor plate of the rifle permitting a firmer and less obstructed grip of the stock. The principal modification directly affecting the accuracy consisted of an enlargement of the bore. The minimum diameter was increased from 0.2175-inch to 0.2180-inch and the maximum from 0.2180-inch to 0.2185-inch and the groove minimum diameter from 0.2225-inch to 0.2230-inch and the maximum from 0.2230-inch to 0.2235-inch. Accuracy is largely dependent upon barrel construction and it is with the barrels that the greatest care is exercised in design, development and manufacture.

The present Springfield rifle, caliber .22, M 1922 M1, the most satisfactory gallery practice rifle ever issued to the service from the point of view of dependable accuracy and rugged construction, is a result of constant refinements through experimentation of the earlier model conceived in 1915 and first accepted in 1920.

Lieut. Arthur D. Elliot, *Ord. Dept., U. S. A.,*
Experimental Department, Springfield Armory.

Machine Gun Activities of Springfield Armory

SPRINGFIELD Armory was the pioneer among Government plants in the manufacture and development of machine guns and their accessories. As far back as 1888 this Armory made modifications on the Gatling gun, such as putting on a safety lock and a method of securing the bolts, both designed by Mr. Murphy. The invention of the Bruce feed to replace the Echels feed for this gun was the work of a local mechanic and this feed was afterward applied to the Lowell and Gardner machine guns.

The Colt, Model of 1902, was the next machine gun issued to the Army. This weapon was for use with the model 1898 rim cartridge and when the new, or rimless, shell was adopted Springfield was given the task of modifying the Colt machine gun to take the new cartridge. This modification consisted of making new bolts, improving the feed wheels, changing the cut-off and making a new extractor as well as cutting off the barrel at the rear end and rechambering for the new shell. All these modifications resulted in a considerable improvement of the gun.

Then came the Maxim Machine Gun, Model 1904. This weapon was not manufactured at Springfield but the Armory designed a new rear sight for it with automatic catch and release and greater windage by ¾-inch each way. Springfield also made the new striker with a removable striker point which was a great improvement over the original one. All the spare parts for this gun as well as for its tripod were manufactured at this Armory.

The Benet-Mercie Automatic Gun, Model 1909, next came into the limelight at Springfield, and after exhaustive tests by the Ordnance Department and a series of field tests by the using services it was adopted. This gun differed considerably from the machine guns previously used being a gas-operated gun and very light in weight. It appealed especially to the Cavalry, being so light and portable that it could easily be slung on a mule or horse and, having a bipod and stock rest attached to the gun, it was very compact and quick to dismount and get into action.

The first lot of these guns was manufactured by the Hotchkiss Company of Paris; later the Colt's Patent Fire Arms Manufacturing Company of Hartford, Connecticut, made several hundred of these guns both for the Army and the Navy. The Benet gun was particularly adaptable to Marine Corps use in connection with quick landings because of the ease with which it could be handled in skirmishing through thickets or swampy country.

The Benet-Mercie was the first machine gun to be manufactured completely by Springfield Armory and, after several suggested modifications, such as a change in the timing, alterations to the bolt and extractor, locking nut and firing pin, all of which were worked out at Springfield, several hundred were manufactured. This plant was the first to mount machine guns on motorcycles and several hundred Benet-Mercie guns were mounted on Indian and Harley Davidson motorcycle sidecars and used with success on the Mexican Border.

Due to the experience gained in assembling, fitting, proof firing and adjusting these guns, together with the knowledge accumulated in performing similar work with machine guns previously in use, men at this Armory became expert machine gun operators, and were soon in demand for instruction purposes and repair work in the field. Several of these men were sent to the Border and more were at once put in training here for field service work. The good work which these men did had the effect of putting the Armory in first place as a service school of instruction for the training of officers, enlisted men and civilians in the mechanical operation of small arms, machine guns and automatic weapons of all types. During the World War a machine gun school was conducted at Springfield which had as many as 300 students at one time and several hundred officers and others completed the course of instructions before the school was discontinued.

During the World War Springfield inspected and tested a certain percentage of the products of the various concerns manufacturing machine guns, automatic rifles, model 1917 rifles, automatic pistols, revolvers and ammunition. This inspection required a large force of both men and women, operating two shifts a day. Millions of rounds of ammunition were used at this time in the testing of the various arms which included the Springfield rifle, Browning machine gun, Browning automatic rifle, Colt automatic pistol, Colt revolver, Smith and Wesson revolver, Marlin machine gun, Lewis machine gun and the model 1917 rifle.

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At the close of the War the repair work on machine guns, automatic rifles, automatic pistols and revolvers assumed major importance and for some time this repair and reconditioning work on automatic arms was one of the major functions of the Armory. This work added a considerable number of makes and types of automatic guns to the variety already handled and included the Browning aircraft machine gun, Marlin aircraft machine gun, Vickers ground type and Vickers aircraft gun, cal. .30 and cal. .11-mm. as well as a Russian model of the Vickers aircraft gun with a speeding up device, also the Lewis aircraft, the Chauchat, Hotchkiss and the Browning tank machine gun.

The Armory soon found itself cramped for room and after utilizing all the space in the old discarded buildings for this work, it was found necessary to erect a new building to accommodate the vast amount of machine gun work accumulating. At this time a new, up-to-date building, three stories high with three under-ground ranges as well as two large proof rooms partially under ground and two synchronizing rooms, was built. The building also includes a small machine shop and velocity ranges, pistol ranges, drafting rooms, photograph and lantern slide department, photostating and blue-print room and offices. It is equipped throughout for experimental and repair work and in it every year are repaired and modified several hundred of the machine guns, automatic rifles and automatic pistols used by the National Guard and the Army.

Springfield Armory has always been deeply interested in the design, development and modification as well as manufacture of automatic and semiautomatic arms and the equipment therefor. Among the most prominent of the semiautomatic rifles of recent date to be designed and developed here are the Garand and Pedersen rifles. Both these rifles have proved their worth and are considered by many to be among the best yet produced. A number of men are now at work putting the finishing touches on the latest models of these guns to have them ready for test.

The Browning automatic rifle was modified at Springfield to the Browning machine rifle, caliber .30. This consisted of changing the barrel to a heavier fin, or rib type, and adding a bipod and stock rest to the equipment. The modification makes the Browning machine rifle especially adapted to Cavalry and Marine Corps use, as the gun is light and very portable and can be fired as many as 800 shots before cooling—a record for air-cooled guns of this type. The bipod, invented at Springfield, is attached to the barrel at the forearm. This bipod gives the operator a swing of 30° laterally while lying prone and the gun can always be kept level whether on side hills or plains by simply rotating the gun either way, the stirrup holding the gun swinging in a 30° arc. The bipod and stock rest fold when the gun is not in use so the gun can be slipped into a boot.

During the last three or four years special attention has been given to the equipment of the antiaircraft forces and Springfield Armory was the first to produce a reliable and up-to-date antiaircraft mount and tripod. This mount since it was first adopted has been modified and improved so that it now accommodates both the caliber .30 and caliber .50 Browning machine guns. The mount is portable, the tripod type and two men can fold it and carry it away in a few seconds. It is easily set up and made ready for action and it is rigid enough to hold its position under the terrible strain of the caliber .50 gun and at the same time flexible enough to help take up the vibration of the guns while in action. These two features are a great aid to the operator while following his target.

The flash hider, another machine gun development of Springfield, has proved a great boon to the antiaircraft troops. This hider was first adopted by the Army in 1923 and bears that model number. It was first intended for use by cavalry and infantry on the caliber .30 Browning machine gun on which it worked out with great success. The antiaircraft forces were sorely in need of something of this character and with slight modification this flash hider was soon put in use on both caliber .30 and caliber .50 antiaircraft machine guns. This hider not only helps to conceal the gun battery while in action, by hiding the terrible blast and flash, but it also reduces the smoke so that the gunner can fire continually at his target instead of firing in bursts, as formerly, since he has a clear view of his target at all times. All of which tends towards greater accuracy and more hits.

An improved cooling device or water circulating system for the Browning or any other water-cooled machine gun is another achievement of Springfield. A regular water box with a hand pump placed inside is used for the caliber .30 gun. Two lines of hose run from the box to the water jacket of the gun, one to the intake, or filler, hole in the water jacket, the other from the steam tube outlet back to the water box. When the operator starts firing, his assistant starts to work the hand pump in the water box. This creates a circulation of the water at once and the continuous flow of the water cools the barrel for a longer period than did the old method. Ordinarily the water is hot and the gun throws steam at 600 rounds at which point fresh water is required. With this cooling device the gun can be fired 1,800 to 2,400 rounds before changing the water. This same principle has been applied to the caliber .50 antiaircraft gun but the water box has been enlarged and the hand pump replaced by a rotary pump so as to supply two guns at once from the same tank or box. The rotary pump is easily operated by turning a crank and the flow of water is such that firing can be continued indefinitely. With the use of either pump there is no steam visible at any time to mar the vision of the gunner.

W. R. BULL,
Foreman, Experimental Department,
Springfield Armory.

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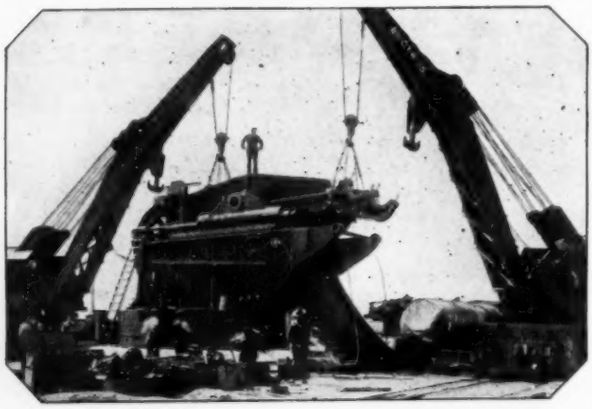

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AOA

Personnel

1928 Reserve Officers' Training Camp at Springfield Armory

IN selecting the writers to set forth a story of the training period, it is apparent that our ability as scriveners is overrated. This calls to mind a story told of a young preacher, who, in announcing his text, intended to say: "Enoch the man, was not, for God took him." What he did say was: "Enoch was not the man God took him for." However, we shall endeavor to give our impressions and reactions.

History is not only a record of the past but is also a prophecy of the future. The old adage, "History repeats itself," is familiar to all. Our history as a nation discloses that we have a war about every twenty-five years. Therefore, it will be seen that some steps should be taken to prepare for future emergencies.

Universal peace is desired by all. We second any movement that contributes in any way to its accomplishment. But we are not deceived by false prophets who cry "peace, peace"—when there is no peace. The millenium has not dawned. Therefore, to forsake military training—a reasonable amount of preparedness along military lines—is likely to be embarrassing. The past teaches very clearly that unpreparedness has been very costly both in human life and money. Practically every war we have had was of greater duration than necessary because of our military policy, or rather lack of it.

The present National Defense Act was framed for the purpose of giving the nation an effective and comprehensive plan of national defense. How effectively it will function depends on the attitude of the public in general, and of reserve officers in particular. We know we can depend on the regulars. Modern warfare has become highly scientific. The developments in combat materials since the World War have been remarkable—so much so that it is apparent that the business of providing arms for the army of the future becomes a greater and greater manufacturing responsibility.

The task of solving this problem is committed to the Ordnance Department. Through the Assistant Secretary of War and the District Offices, industrial preparedness is developing along the lines of the most up-to-date mass production methods. The rapid development of the arts and sciences has been directly applied in a practical way in mechanizing all army matériel. The manufacturing plant producing ordnance matériel, as well as the army in the field, demands highly trained specialists, in order that the maximum production can be obtained in the minimum time.

It is evident that the Reserve Officer can materially assist in this phase of the problem. His daily vocation demands that he keep himself well informed on the latest processes and production methods. Such experience can be adapted readily to the Ordnance production problem—in the early stages of an emergency when expansion becomes necessary. Proper training will expedite production and prevent overlapping of effort. It is all a matter of preparedness.

Having the foregoing in mind, a large, well trained reserve corps is a real necessity in peace time. However, its value will depend on the interest reserve officers take in trying to determine where and how any specialized knowledge they have may be used in time of emergency. The Ordnance Department through the correspondence courses and training camps endeavors to help the reserve officer maintain proper contacts with the regular establishment for that purpose.

The objective for the Class of 1928 at Springfield Armory is clearly stated in Memorandum Orders No. 28, paragraph 9, dated Springfield Armory, Mass., May 8, 1928: "This course of instruction is organized primarily for the purpose of giving as much instruction as possible in their duties to Ordnance reserve officers assigned to Ordnance maintenance companies, particular stress being laid on work connected with the repair and maintenance in the field of rifles, pistols, revolvers, automatic arms and machine guns, and instruction in the routine duties of administration of a company. At the same time a considerable part of the course covers instruction which is of direct benefit to reserve officers assigned to District Offices as production assistants or inspectors at small arms manufacturing plants." This developed into a highly intructive and interesting program as will be shown in the following record.

Through the rain and mists, and under the lowering skies of a rather disagreeable Sunday afternoon, the Class of 1928 reported to the Commanding Officer at Springfield Armory for a period of 14 days active duty—May 20 to June 2, inclusive. Through the courtesy of the Commanding Officer, Colonel H. W. Schull, Ord. Dept., U. S. A., we were assigned to quarters on the officers' line.

The boom of the morning gun on May 21, reminded us that we had left civil life behind and once again had passed to active status, as officers in the U. S. Army. At 8:00 A. M. we reported at headquarters of the Armory and were welcomed by the regular army officers attached to the post.

The schedule of instruction provided for an inspection tour of the establishment. This took the balance of the morning. In the afternoon we visited the museum. Here is assembled a large collection of arms dating back to pre-Revolutionary War days. The collection of arms started some time after the establishment of the Armory—the exact date not being known. Mr. Robert Lee was appointed custodian in 1906. Specimens are sent to him and he cleans, allocated and catalogues them, maintaining a card record of each piece, giving description and any interesting data concerning it.

There are examples of Springfield manufacture, of every type of musket and rifle, except the original musket of 1795. It is an item of interest to note that the original Springfield musket weighed nine pounds; and that down through the years since, the weight of the infantry weapon has remained about the same. The present model weighs 8.69 pounds.

The collection of arms was started for the purpose of comparison and design. It was limited to muskets, sabers, swords and bayonets. In the course of years Ordnance officers traveling abroad gathered specimens which they thought might be of interest to the experts at the Armory. The museum is international in scope—weapons from practically all countries of the world being in the collection.

It would be impossible to give a detailed story of all we saw. Many hours more than our assignment could be

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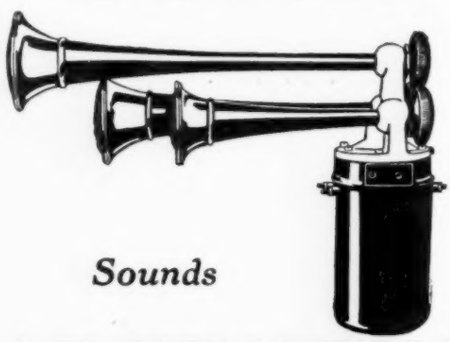

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profitably spent in the museum. Interesting specimens of German matériel, taken in the World War, including articles made of paper in the latter days of the war, when leather became scarce in Germany, are there, including a set of harness for an artillery team, made almost entirely of paper. The present condition and fine appearance of the museum reflects considerable credit on those responsible for it.

On May 22, Captain S. J. Raymond, Infantry, U. S. A., lectured at 8:00 A. M. on the subject: "Tank Maintenance." In his lecture he followed the movement of the tanks from the tank park up through the combat zone to rallying point after engagement with the enemy. He told us about the organization of heavy and light tank missions, explaining just how heavy ordnance repair shops functioned in maintaining them, and keeping them ready for action.

Following Captain Raymond's lecture, Colonel Read introduced Major Brooks, Office of the Chief of Ordnance, Washington, D. C., who outlined the policy of the Ordnance Reserve Corps with reference to assignments, hours of credit, correspondence courses, etc. He explained what is required to retain present active status as Ordnance reserve officers, also eligibility regulations for promotion.

At the conclusion of Major Brooks' address the class adjourned to the Water Shops. In the interest of economy all machine work on the metal components of the Springfield Rifle is done at the Water Shops, where power is obtained from a water-operated turbine. Starting at the Forge Shop the class proceeded to the forge, press and annealing departments, inspected the electric generator, continuing on through the machine, barrel, receiver, milling and sight shops and the polishing room. After the noon recess we continued through to the planning room.

The small percentage of labor turnover is evident in the smooth running of the various departments. There are employees who have worked here twenty, thirty and forty years. An examination of the material in process of manufacture showed a very high standard of workmanship.

The following day began with a lecture by Capt. E. L. Upson, Infantry, U. S. A., on "Customs of the Service." This lecture was very helpful and instructive from a reserve officer's point of view, since we do not have the contacts with regular army life to keep posted on the customs of the service. This feature of the course should be maintained in all reserve officers' training courses, if for no other reason than to make the new officer acquainted with what is expected of him in his relations with other officers. We were much interested in Captain Upson's remarks concerning dress and general personal appearance, with reasons therefor.

We then visited the stocking shop, case hardening department and laboratory. The process of manufacturing stocks from the raw material to the finished state proved of unusual interest to those of us who were not familiar with wood working.

The sequence of operations in heat treating various components was explained in detail by Mr. Oliver, metallurgist, who has a thorough knowledge of his profession. Springfield Armory is obtaining splendid results in annealing and case hardening various components of the Springfield rifle. We spent the remainder of the morning in the parkerizing and browning departments. The rust-proofing of exposed metal parts of the rifle is taken care of by these processes—the usual commercial practice being followed.

In the afternoon we visited the gage inspection department. This section has the custody of and responsibility for all gages used at this arsenal in the manufacture of small arms. A card system is maintained, whereby a record is kept giving a description and location of all gages. Mr. Toomey, in charge of this department, is well qualified through years of study and practical experience.

We also reported to the Experimental Building to witness a demonstration of the Garand caliber .30 and Pedersen caliber .276 semiautomatic rifles. There is considerable merit in both weapons. Mr. Garand was present and explained in detail the principle and operating mechanism of his semiautomatic rifle.

Thursday, May 24, the class motored to the plant of the Winchester Repeating Arms Company, New Haven, Connecticut. We were given a most cordial reception by Mr. Pugsley, factory manager, under whose personal supervision we made a complete tour of inspection of that portion of the plant devoted to the manufacture of firearms. The system of production is a fine example of modern factory efficiency. It is evident that much time and study have been spent in its development and perfection. Concluding the morning tour we assembled in the directors' room and were addressed by Mr. Pugsley on the Winchester Repeating Arms Company's method of gage inspection. He then gave a gage checking demonstration of the method. On behalf of the Winchester Repeating Arms Company, he presented each officer with very attractive flash lights, after which they were guests of the company at luncheon.

After luncheon we were shown through the ammunition department, where many of us saw for the first time the very interesting operations necessary in making a complete round of ammunition. This was particularly practical since we were studying the rifle, pistol and automatic machine gun. We cordially thanked Mr. Pugsley and his able staff for their hospitality, and returned to quarters at Springfield, where we all agreed that this day had been one of much profit and interest.

The following day the three sections reported to Messrs. Gibson and Woodworth for study and targeting of the caliber .22 and National Match rifles. These men are highly efficient experts in the design of firearms of all kinds. Years of experiment and development in their chosen field have given them a very complete knowledge of the art. The hours spent under their instruction were of real value and their hints on good marksmanship were greatly appreciated.

At noon, after an early mess, we left for an inspection trip to the Colt's Patent Firearms Manufacturing Company's plant, Hartford, Connecticut. Their system of manufacture was explained to us by Mr. Stevens, of the staff—a very affable gentleman. After visiting the various departments which manufacture small arms, as well as the shops which are making the bakelite and electrical fixtures, we reached the conclusion that here is a great factory, with large capacity for the manufacture of arms in the event of a national emergency.

On Saturday, May 26, a lecture was given by Major J. K. Clement, Ord. Dept., U. S. A., on "District Ordnance Office Activities." He cited as an example the organization and operation of the Bridgeport District Ordnance Office. Major Clement outlined in detail the forms and methods pursued in district office procurement. He explained in detail how manufacturers are approached with reference to manufacturing Ordnance matériel in emergency. Also

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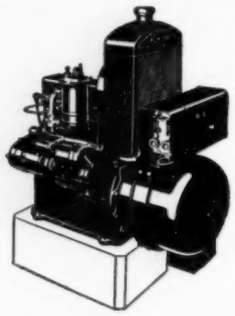

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he explained production and inspection plans and organization. Major Clement's talk was exceedingly thorough and instructive. We wish each reader might have heard it.

Captain Raymond followed with a very interesting talk on his experiences in Siberia with the Russian Expedition. Many hardships were suffered due to the rigor of extremely cold weather—the thermometer reaching 60° below zero. He also related incidents filled with humor and pathos in connection with that expedition. We were sorry that Captain Raymond did not have time to go more into detail concerning encounters and experiences with the Bolshevik forces. We commend him to you as a lecturer on this extremely interesting subject. Any group of reserve officers would thoroughly enjoy every minute of his talk.

We spent all day Monday, May 28, in the assembly shop under the supervision of Mr. Fletcher and his assistants. It was our first opportunity to take the rifle and pistol apart and put them together again. While we could not compete with mechanics who have been doing this work for so many years, we appreciated the opportunity to know more about the functioning of these pieces. The day was entirely too short for the majority of us—as we were learning many fine points about guns and pistols. We learned where to look for defects, as well as more about rifle and pistol construction, repair, boresighting and final inspection.

Major Herbert O'Leary lectured to us on Tuesday, May 29, on "Post War Development of Small Arms." Major O'Leary recounted the technical advance of the art since the war. He explained the several investigations intended to prevent rust and prolong the life of barrels in the service rifle, pistol and machine gun. He explained the importance of accuracy, durability and maintenance of small arms; the relative merits of the Garand and Pedersen semiautomatic rifles, and the improvements in the caliber .50 machine gun with respect to rate of fire. This was no doubt one of the most interesting lectures we heard during the course of instruction.

The balance of the day was spent in the experimental building, studying field inspection and maintenance of small arms, including machine guns. Occasionally something happens which causes a rifle to fail in service. Naturally the manufacturing arsenal wants to know about it, so that any defects in material or design can be corrected in future manufacture. Mr. Woodworth explained the various means of determining causes of failures, and suggested ways and means of securing data concerning them. Such information, together with the piece involved, should be sent to those interested for further examination and study.

It is evident that practically all trouble can be traced directly to lack of care by allowing foreign substances to be left in the barrel. The method of proof firing at Springfield Armory is so well conducted, it is practically impossible for defective material in any component to get by the rigid inspection.

An interesting study on semiautomatic rifles and machine guns was conducted by Mr. Bull. He told of recent experiments tending to increase rate of fire in machine guns, and gave us much information concerning operation, care, etc., of this type of weapon. It was delightful to have a discussion with such an able and experienced mechanic, and the lessons learned will not be forgotten.

The next day the scene of activity was at the Water Shops. Our previous visit concerned production methods; now we were to study shop inspection in all its ramifica-

tions. If care is shown in manufacturing, and it is, this vigilance is doubled in this department. The percentage of rejects in final inspection is not known to us, but it must necessarily be small, due to the careful check conducted by the shop inspectors. To the uninitiated it seems like a waste to go over the various parts in process so often, but it really is economy as it prevents work being done on parts that would not pass final inspection. Precision also builds *esprit de corps* which results in more and better workmanship.

Mr. Hosmer, chief inspector, has a splendid organization. Their interest in their work is a matter of pride with them. Obviously we asked some foolish questions, but their patience never failed them. They seemed intent on giving us all the information covering this part of the manufacturing program possible.

At 2:30 P. M. we returned to the administration building to attend a lecture by Mr. Elmer Bryant, of the Engineering Staff, Greenfield Tap and Die Company. He told us of the difficulty in developing gages for some of the more complicated components of the Springfield rifle, taking as an example, the receiver. He then explained the wire method of measuring threads, showing that a great degree of accuracy was obtained by following this method. His address was of necessity very technical, but he handled it in a very helpful way.

The exercises on Friday, June 1, opened with an address on "War Time Procurement and Issue of Munitions." Captain D. G. McGregor, Ord., Dept., U. S. A., who gave the address, presented a graphic description of the Ordnance problem as related to district office procedure. He explained why district offices were instituted and told us why decentralization was necessary in war time. Some of us were familiar with district office activities, due to our service during the World War. Captain McGregor stated that the reserve officer should familiarize himself with the National Defense Act, as a duty, in view of his oath as a reserve officer. In other words, the reserve officer's training should qualify him to sell preparedness to the rank and file of those fellow-citizens who have little or no interest in the matter.

Captain McGregor explained district office procurement methods, and stated success depended upon the placing of "educational orders" with contractors, who have shown a spirit of coöperation in the development of our industrial preparedness program by taking procurement schedule acceptances. In the interest of economy each contractor receiving such an educational order should be required to submit a plan showing how he proposes to manufacture and complete the order. Trusting to the judgment of the mechanic, poor tool designing, lack of proper jigs and fixtures, faulty gages and inspection methods are elements that must be watched. Captain McGregor delivered his address in a forceful manner and conveyed to the class his enthusiasm and interest in preparedness.

The afternoon was given over to the writing of final reports covering the course.

Thursday evening, May 31, Colonel and Mrs. Schull entertained the officers of the post and attached officers, their wives, and the reserve officers, at tea. Mrs. Schull is a charming hostess. We had a delightful time. The class will carry away pleasant memories of its social contacts on this tour of active duty.

On Friday night, June 1, Captain Hambleton, Lieuten-

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ants Hapgood and Lindley, serving as a committee representing the reserve officers, gave a dinner to the officers of the post and attached officers at the Nayasset Club. Our guests were Colonel Schull, Lieutenant-Colonel Read and Lieutenant McInerney of the Post, Col. B. A. Franklin, Major Clement and Captain McGregor of the Bridgeport District Ordnance Office, and Captain Coulter on detached duty with the National Guard. Lt.-Col. A. L. Mercer, Ord. Res., presided at the dinner and was toastmaster.

Colonel Schull gave us a very interesting talk on preparedness and its part in the scheme of national defense. He is tremendously interested in the Ordnance Reserve, both as to personnel and matériel. His desire that everything possible be done to make the course helpful, and the constant contact he maintained with us during study periods and lectures, assured us of his sympathy. His fine spirit, his friendliness and personal charm captivated each one of us. This attitude on his part has left an impression on us that will last many years, and stimulate us to greater endeavor in the common cause of national preparedness.

Lieutenant-Colonel Read's remarks concerning the development of our own individuality and character were inspiring and to the point. We owe Colonel Read a debt of gratitude for the splendid course and excellent way in which it was conducted.

Following Colonel Read, Colonel Franklin gave a brief outline of his interpretation of the reserve officer's responsibilities in time of peace.

Major Clement, Captain Coulter and Lieutenant McInerney also gave brief talks which were enjoyed and appreciated. Colonel Root, on behalf of the reserve officers, thanked the officers of the post for their many courtesies and favors. We closed with the singing of Auld Lang Syne and America. Thus the Class of 1928 passed into history.

Capt. R. E. Goho, *Ord. Res., U. S. A.*,
Lieut. W. W. Cummings, *Ord. Res., U. S. A.*

Summer Training for Ordnance Reserve Officers

As of June 19, 1928, the following Ordnance Reserve Officers are ordered to active duty training at the places and for the periods indicated:

Raritan Arsenal: July 29 to August 11. 1st Lieut. Joseph A. Llompart.

Philadelphia District Ordnance Office: July 8 to July 21. Capt. Theodore J. Snyder.

Frankford Arsenal: July 8 to July 21. 1st Lieut. Herbert H. Mitchell.

Command and General Staff Course "D," Camp Gettysburg, Pa.: July 8 to July 21. Lt. Col. Frederick C. Bull.

Ft. Riley, Kans.: July 15 to July 28. Maj. William C. Bliss.

Fort Lewis and Fort Casey, Wash.: July 5 to July 18. Maj. Welton J. Crook.

New York District Ordnance Office: August 1 to August 14. Maj. Carlos de Zafra.

Washington, D. C.: July 15 to July 28. Capt. Roy S. Haggard; August 5 to August 18, Maj. Emil F. Norelius; August 19 to September 1, 1st Lt. Arthur H. Nordstrom.

Pittsburgh District Ordnance Office: July 1 to July 14. Capt. Frank N. Sarber.

Fort Sam Houston, Texas: September 9 to September 22. Capt. Hugh E. Coleman.

Picatinny Arsenal: August 12 to August 25. Lt. Col. Hardee Chambliss.

Watertown Arsenal: July 8 to July 21. Capt. Clarence E. Gage. July 15 to July 28. 1st Lt. Waldo L. Emerson.

Cincinnati District Ordnance Office: July 15 to July 28. Capt. Oliver M. Leath.

Springfield Armory: August 20 to September 1. 1st Lieut. Alfred G. Ashcroft.

Fort Leonard Wood, Md.: July 8 to July 21. Col. Fred. H. Wagner.

Rock Island Arsenal: July 8 to July 21. Lt. Col. Hugo Diemer, Majs. Allen C. Harris, George H. Higgins and Herbert B. McKahin; Capts. Benjamin H. Ball and Abraham M. Ehrlich; 1st Lieuts. Charles R. Burlingame, Burns C. Cox, Justin J. Hanaw, George L. Hunt, Joseph P. O'Hern, Joseph Proske, Jay E. Rohrer and Rufus R. Rosell; 2nd Lieuts. Edward C. Bopf, Francis A. Hennigan, John O. Johnson, Olen B. Shawhan and Stewart R. Scott. August 19 to September 1st. 1st Lieut. Justus Rising.

Aberdeen Proving Ground: July 1 to July 14. Maj. Kenneth L. Holmes. July 29 to August 11. Col. James Guthrie; Lieut. Colonels George S. Brady, Wm. M. Hogg and James D. Skinner; Majors James B. Arthur, John H. Barrett, Paul W. Bidwell, Charles K. Blatchly, Harold M. Brayton, Clarence E. Davies, Lyman M. Dawes, Geo. W. Franzheim, Walter W. Golden, Sheldon D. Graff, Charles J. Jeffers, James W. Mailler, Joseph D. Murray, Ellis R. Northrop, Andrew M. Platoff, Charles F. Queisser, Zeliffe P. Smith, and Carl A. Wendell; Captains Nathan C. Avery, Bert F. Baker, Byron W. Benedict, Don P. Carpenter, Manly A. Collins, Wm. F. Costello, Kenneth M. Cunningham, Stanley Dewsnap, George R. Ensminger, Harold S. Eroe, Geo. J. Eyrick, Richard J. Forsyth, Herman P. Gould, Norman Hicks, Warren B. Hood, Arthur F. Hubbard, Robert J. Johnson, George H. Knode, David A. Lenk, Harry I. Lewis, Howard Logan, Henry N. Marsh, Henry H. Olmstead, Richard E. Pohle, Edward H. Sager, Harold E. Schofield, Otto R. Schurig, Wm. E. Sidney, Floyd L. Strawn, Carroll P. Thweatt, Kenneth I. Tredwell, Walter D. Tyler, Arthur F. Van Buskirk, Seth Wiard, William B. Williams and Clyde R. Yates; 1st Lieutenants Hiram B. Channon, Harry P. Croft, Raymond E. Curly, John F. Drennan, LeRoy C. Ensminger, Donald C. Fabel, Taylor B. Grant, Norman C. Hepburn, Charles E. Herrstrom, Harry A. Hirsch, John H. Johnson, Wm. Kendall, Tracy C. Kerr, Robert J. King, Geo. H. Leavitt, Douglas F. Linsley, Kenneth C. Monroe, Richard C. Mugler, Paul F. Mumma, Stuart Naramore, Henry E. Passmore, Vergil C. Pritchett, Daniel H. Reed, Wm. W. Richardson, Gilbert I. Ross, Roland W. Sellew, Fred L. Tanner, Jr., and Henry R. Zayotti; and 2nd Lieutenants John E. Bergain, Donald R. Biron, Rudolph S. Breseka, Charles L. Bullock, Joseph L. Carroll, William M. Croft, Raymond G. Curtin, Ralph L. Dunckel, Leo F. Dunn, John J. Egan, Bernard S. Franklin, Wm. F. Gallagher, Louis E. Gates, Charles J. Gibbs, Edward Gluck, Arthur W. Haley, Edgar F. Heselbarth, James H. Howard, Henry A. Huckaba, Lloyd W. Irving, Paul K. Klaesius, Joseph F. Lacchia, Leonard A. Lefeort, Theodore E. Lorenz, Ivan W. Lord, Edward R. Melton, Joseph G. Moffett, Nelson H. Mosher, Henry S. Moulthrop, Ralph S. Nagle, Harry S. Nelson, Thomas M. O'Neil, Charles T. Schulz, Floyd B. Shannon, Harold D. Shierman, Robert E. Smith, Terrence S. Tanney, Clinton M. Vernon, Nicholas R. Wilson, Louis M. Wolford, Fenton R. Young and Harold S. Young.

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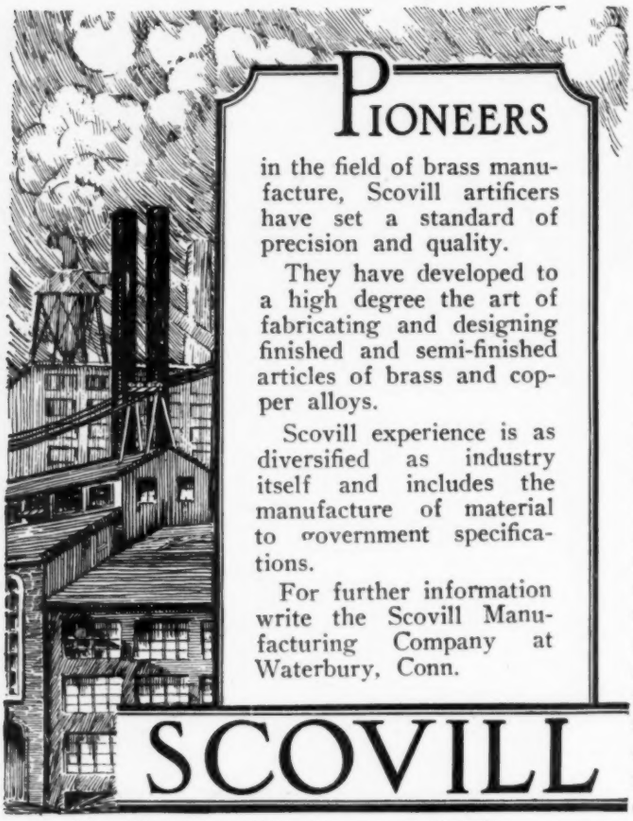
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Books

The Spanish-American Frontier: 1783-1795; The Westward Movement and the Spanish Retreat in the Mississippi Valley. By Arthur Preston Whitaker. New York: Houghton Mifflin Company. 1927. $3.50.

A VERY clear understanding is obtained from this thorough and authoritative history of the intrigue and diplomacy concerning the western frontier of the United States during the twelve years concluding with 1795. The author has made extensive investigations of available sources in order to obtain the true history, of this period in which the Mississippi River, the western frontier, played such an important role. Dr. Whitaker analyses the character of the famous and notorious personages who had much to do with the settlement of the vexatious boundary questions. The formal treaties with the Indian "Nations" and the agreements with the fur traders are typical of the period and interestingly recounted. The land jobbing schemes which were launched and the attitudes of the several state legislatures involved have not been extensively recorded heretofore. In the present volume that fature of our early history is ably presented together with a clear and complete picture of the great difference between the civilizations represented by the rough backwoodsman of the west and the courtly diplomats of the Spanish Throne.

Peace or War? By Lt. Commander J. M. Kenworthy, M. P. New York: Boni and Liveright. 1927. $2.50.

IN this book Commander Kenworthy, formerly a British naval officer, and now a leader of the Labor party in Parliament, describes the war of the future as an attack on entire civil populations in a successful attempt to show the devastating effects of warfare with modern weapons. It is to be feared that his emphasis on the potentiality of gas and air attack will not be recognized by the civilian, in spite of his vivid language, when one considers that in England as well as other countries "the bow-and-arrow mentality predominates once more" among leaders of the armed forces. It is the country whose soldiers succeed best in replacing the experiences of the last war with a fresh point of view who will have the jump on the other fellow.

Statesman and Friend Correspondence of John Adams with Benjamin Waterhouse, 1784-1822. By Worthington Chauncey Ford. Boston: Little, Brown and Company. 1927. $3.00.

IN these recently discovered and hitherto unpublished letters of our second President to Professor Waterhouse is much to further the understanding of the reader concerning the character of this historical figure.

They present in an informal way his ideas concerning polities, education, and other topies of the day and show how varied were his interests and how thoroughly he understood the true state of affairs generally. They are a great contribution to the early history of the United States.